# NAVAL POSTGRADUATE SCHOOL
# Monterey, California


# THESIS

**AN ANALYSIS OF THE TAIL TO TOOTH RATIO AS A MEASURE OF OPERATIONAL READINESS AND MILITARY EXPENDITURE EFFICIENCY**

by

Tamara L. Campbell
Carlos H. Velasco

December 2002

Thesis Advisor: John Mutty
Co-Advisor: Bill Gates

THIS PAGE INTENTIONALLY LEFT BLANK

# REPORT DOCUMENTATION PAGE

*Form Approved OMB No. 0704-0188*



| 1. AGENCY USE ONLY *(Leave blank)* | 2. REPORT DATE | 3. REPORT TYPE AND DATES COVERED |
|---|---|---|
| | December 2002 | Master's Thesis |

**4. TITLE AND SUBTITLE**
An Analysis of the Tail to Tooth Ratio as a Measure of Operational Readiness and Military Expenditure Efficiency

**5. FUNDING NUMBERS**

**6. AUTHOR (S)** Tamara L. Campbell and Carlos H. Velasco

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
Naval Postgraduate School
Monterey, CA 93943-5000

**8. PERFORMING ORGANIZATION REPORT NUMBER**

**9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)**
N/A

**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**

**11. SUPPLEMENTARY NOTES** The views expressed in this thesis are those of the author and do not reflect the official policy or position of the U.S. Department of Defense or the U.S. Government.

**12a. DISTRIBUTION / AVAILABILITY STATEMENT**
Approved for public release; distribution is unlimited

**12b. DISTRIBUTION CODE**

**13. ABSTRACT** ***(maximum 200 words)***

The Tail-to-Tooth Ratio (TTR) expresses the relationship between the resources or forces employed to perform the core missions and the resources or infrastructure used to manage and support those forces. Several methods are used in DoD to measure the TTR, all of which attempt to establish an unambiguous boundary between "tail" and "tooth." Specific cases and examples confirm that such a clear-cut limit does not exist. On the contrary, the definitions of "tail" and "tooth" change with the specific situation, the environment and the timing of the measurement.

The lack of a clear boundary suggests that the relationship between "tail" and "tooth" should not continue to be expressed as a ratio or a mathematical relationship between two numbers, but as a continuum. The "Tail-to-Tooth Continuum" can be represented in more than one dimension in relation to the number of variables used to characterize the position of a specific activity on the continuum.

This new approach focuses on outputs and outcomes and could prevent the unnecessary labeling of costs, allowing management to concentrate on increasing efficiency and reducing the total costs of attaining DoD's desired outcomes.

| 14. SUBJECT TERMS | 15. NUMBER OF PAGES |
|---|---|
| Tail-to-Tooth Ratio, DoD Force Structure, DoD Infrastructure, Tail-to-Tooth Continuum, DoD Tail, DoD Tooth | 171 |
| | 16. PRICE CODE |

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| Unclassified | Unclassified | Unclassified | UL |

**NSN 7540-01-280-5500** **Standard Form 298 (Rev. 2-89) Prescribed by ANSI Std. 239-18**

THIS PAGE INTENTIONALLY LEFT BLANK

**Approved for public release; distribution is unlimited**

# AN ANALYSIS OF THE TAIL TO TOOTH RATIO AS A MEASURE OF OPERATIONAL READINESS AND MILITARY EXPENDITURE EFFICIENCY

Tamara L. Campbell
Captain, United States Marines Corps
B.S., United States Naval Academy, 1997

Carlos H. Velasco
Captain, Colombian Navy
B.S., Colombian Naval Academy, 1980
M.S.E.E., Naval Postgraduate School, 1992

Submitted in partial fulfillment of the
requirements for the degree of

**MASTER OF SCIENCE IN MANAGEMENT**

from the

**NAVAL POSTGRADUATE SCHOOL**
**December 2002**

Authors:

Tamara L. Campbell  Carlos H. Velasco

Approved by:

John Mutty
Thesis Advisor

Bill Gates
Associate Advisor

Douglas A. Brook, Ph.D.
Dean, Graduate School of Business and Public Policy

THIS PAGE INTENTIONALLY LEFT BLANK

# ABSTRACT

The Tail-to-Tooth Ratio (TTR) expresses the relationship between the resources or forces employed to perform the core missions and the resources or infrastructure used to manage and support those forces. Several methods are used in DoD to measure the TTR, all of which attempt to establish an unambiguous boundary between “tail” and “tooth.” Specific cases and examples confirm that such a clear-cut limit does not exist. On the contrary, the definitions of “tail” and “tooth” change with the specific situation, the environment and the timing of the measurement.

The lack of a clear boundary suggests that the relationship between “tail” and “tooth” should not continue to be expressed as a ratio or a mathematical relationship between two numbers, but as a continuum. The “Tail-to-Tooth Continuum” can be represented in more than one dimension in relation to the number of variables used to characterize the position of a specific activity on the continuum.

This new approach focuses on outputs and outcomes and could prevent the unnecessary labeling of costs, allowing management to concentrate on increasing efficiency and reducing the total costs of attaining DoD’s desired outcomes.

THIS PAGE INTENTIONALLY LEFT BLANK

# TABLE OF CONTENTS


I. INTRODUCTION ..... 1
A. PURPOSE ..... 1
B. BACKGROUND ..... 2
C. RESEARCH QUESTIONS ..... 2
D. SCOPE ..... 3
E. RESEARCH METHODOLOGY ..... 3
F. THESIS ORGANIZATION ..... 4

II. DETERMINATION OF THE TAIL TO TOOTH RATIO ..... 7
A. INTRODUCTION ..... 7
B. CURRENT PROCESSES/POLICIES REGARDING TAIL TO TOOTH RATIO MEASUREMENT ..... 8
1. Cost of Fighting Forces Versus Support Structures ..... 9
*a) Force Structure vs. Infrastructure Approach ..... 9*
*b) Major Force Programs and Program Elements (PE) ..... 16*
2. TTR Relationship to Combat and Support Personnel ..... 21
3. Procurement Programs and Projects ..... 22
C. CURRENT TTR IN THE DEPARTMENT OF DEFENSE ..... 23
1. Calculation Using the Force Structure vs. Force Infrastructure Approach ..... 23
2. Calculation Using MFPs Approach ..... 28
3. Calculation Using Personnel Approach ..... 32
4. Advantages and Disadvantages of Each Method ..... 34
D. CHAPTER SUMMARY ..... 35

III. HISTORICAL PERSPECTIVE OF THE TTR ..... 37
A. INTRODUCTION ..... 37
B. ANCIENT MILITARY TRENDS ..... 38
C. EARLY MILITARY SOCIETIES ..... 39
D. THE LOGISTICS OF THE MACEDONIAN ARMY ..... 41
E. THE ROMAN LEGIONS ..... 42
F. MILITARY SYSTEMS IN THE FEUDAL ERA AND MIDDLE AGES ..... 43
G. TAIL TO TOOTH RATIO IN THE UNITED STATES MILITARY ..... 45
H. SUMMARY ..... 48

IV. ANALYSIS OF THE INFLUENCE OF TECHNOLOGICAL ADVANCES IN THE TTR ..... 51
A. INTRODUCTION ..... 51

B. REDUCTION IN THE TAIL AS A DIRECT EFFECT OF ADVANCES IN TECHNOLOGY .....51
C. INCREASE IN THE "TAIL" AND/OR REDUCTIONS IN THE "TOOTH" AS A DIRECT EFFECT OF ADVANCES IN TECHNOLOGY .....52
D. PRECISION-GUIDED ORDNANCE AND LONG-RANGE UNMANNED SYSTEMS .....57
E. CHAPTER SUMMARY .....60

V. ANALYSIS OF THE RELATIONSHIP BETWEEN TTR AND OPERATIONAL READINESS .....63
A. INTRODUCTION .....63
B. IMPACT OF MAINTENANCE LEVEL DESIGN ON THE TTR .....63
C. RELATIONSHIP BETWEEN OPERATIONAL READINESS AND THE TTR .....67
D. CHAPTER SUMMARY .....72

VI. TAIL TO TOOTH RATIO WITHIN THE CORPORATE WORLD .....75
A. INTRODUCTION .....75
B. TAIL TO TOOTH DEFINITION IN THE CORPORATE WORLD ...76
1. Overhead Versus Direct Cost .....76
2. Selling, General and Administrative Cost (SG&A) Versus Cost of Goods Sold .....77
*a) Activity Based Costing (ABC) .....78*
3. Primary Versus Supporting Activities .....80
*a) Value Chain Analysis .....82*
C. SUMMARY .....84

VII. A NEW APPROACH TO THE "TAIL-TO-TOOTH" RATIO .....87
A. INTRODUCTION .....87
B. CURRENT DOD TTR DEFINITIONS UNDER FLUCTUATING CIRCUMSTANCES .....87
1. The Situationally Dependent Boundary Between "Tail" and "Tooth" .....88
2. The Environmentally Dependent Boundary Between "Tail" and "Tooth" .....91
3. Time-Based Boundary Between "Tail" and "Tooth" .....94
C. TTR BASED ON AN OUTPUT/OUTCOMES MEASUREMENT SYSTEM .....98
1. TTR of the Special Operations Forces (SOFs) Based on an Output and Outcomes Measurement System .....101
*a) SOFs Missions, Collateral Activities and Organization .....102*
*b) Defining the TTR of the SOFs According to Primary and Support Activities .....103*
D. "TAIL" AND "TOOTH" AS A CONTINUUM .....107

E. CHAPTER SUMMARY .....111
VIII. CONCLUSIONS AND RECOMMENDATIONS .....115
A. INTRODUCTION .....115
B. SUMMARY OF RESEARCH FINDINGS .....115
C. ANSWERS TO RESEARCH QUESTIONS .....118
D. AREAS OF FURTHER RESEARCH .....123
APPENDIX A .....125
APPENDIX B .....131
APPENDIX C .....133
LIST OF REFERENCES .....141
INITIAL DISTRIBUTION LIST .....147

THIS PAGE INTENTIONALLY LEFT BLANK

# LIST OF FIGURES

Figure 2-1, MFP Structure .....17
Figure 2-2, Variations in Force Structure and Force Infrastructure Categories.....24
Figure 2-3, Variations in Infrastructure According to the Allocation of DWCF.....26
Figure 2-4, Percentage Yearly Variation in the Budget .....27
Figure 2-5, Percentage Yearly Variation in the “Force Categories” Budget.....27
Figure 2-6, Combat Forces MFPs Vs. Infrastructure MFPs .....28
Figure 2-7, Appropriation Distribution within Combat Forces MFPs.....29
Figure 2-8, Variations in Infrastructure According to the Allocation of DWCF Between the MFPs.....29
Figure 2-9, Combat Forces MFPs Vs. Infrastructure MFPs .....30
Figure 2-10, Appropriation Distribution within Combat Forces MFPs.....31
Figure 2-11, Variations in Infrastructure According to the Allocation of DWCF Between the MFPs.....31
Figure 2-12, Combat Manpower vs. Support Manpower .....32
Figure 2-13, Ratio of Combat Manpower to Total Manpower by Services.....33
Figure 3-1, Size of the DoD “tail” Since the Introduction of the PPBS.....48
Figure 3-2, Evolution of the TTR Based on the “Combat vs. Support Personnel” approach.....49
Figure 4-1, Some Values of the Normalized Comparative Operational Lethality Indices.....54
Figure 5-1, Historical Life-Cycle Cost Breakdown of a Weapon System.....64
Figure 5-2, Costs Normally Considered Infrastructure Grouped by Appropriation Category (Fiscal Years 1996-2001).....64
Figure 5-3, Operational Availability for Different Repair Times and Sparing Levels.....71
Figure 6-1, Porter Value Chain Model Primary vs. Support Activities.....80
Figure 6-2, Commonalities in the Definitions of “Tail” and “Tooth” in the Corporate World.....85
Figure 7-1, USSOCOM Organization .....103
Figure 7-2, Core Competencies and Products of the SOFs .....104
Figure 7-3, From a Fixed-Boundary to a Continuum Concept ...108

Figure 7-4, Example of Locating a SOFs Unit on a Two Dimensional “Tail to Tooth Continuum”.....109
Figure 7-5, Three Dimensional “Tail to Tooth Continuum” ....110

# LIST OF TABLES

Table 2-1, Changes in the Force or Mission Categories .....12
Table 2-2, Changes in Infrastructure Categories .....12
Table 6-1, Commonalities in the Definitions of “Tail” and “Tooth” in the Corporate World.....84
Table 7-1, SOFs’ Principal Mission Areas and Collateral Activities.....102
Table 7-2, Example of Defining the SOFs TTR Using Primary and Support Activities.....105
Table A - 1, Department of Defense TOA by Force and Infrastructure Categories.....125
Table A - 2, Department of Defense TOA by Major Force Programs Assuming 6 MFPs as “Combat Forces Programs”.....126
Table A - 3, Department of Defense TOA by Major Force Programs Assuming only 3 MFPs as “Combat Forces Programs”.....127
Table A - 4, Defense-Wide Working Capital Fund FY 2003 Budget Estimates, Orders from DoD Components...128
Table A - 5, Department of Defense Active-Duty Military and Civilian Manpower by Force and Infrastructure Categories.....128
Table A - 6, Active-Duty Military and Civilian Manpower by Services and by Force and Infrastructure Categories.....129
Table B - 1, Comparative Operational Lethality Indices .....131
Table B - 2, Normalized Comparative Operational Lethality Indices.....132

THIS PAGE INTENTIONALLY LEFT BLANK

# LIST OF ACRONYMS

ABC ..... Activity Based Costing
Ao ..... Operational Availability
C3 ..... Command, Control, and Communications
C4I ..... Command, Control, Communications, Computer, and Intelligence
COGS ..... Costs of Goods Sold
DBOF ..... Defense Business Operations Fund
DERF ..... Defense Emergency Response Fund
DoD ..... United States Department of Defense
DoN ..... Department of the Navy
DPPC ..... Deployable Print Production Center
DSB ..... Defense Science Board
DWCF ..... Defense Working Capital Fund
FMS ..... Foreign Military Sales
FYDP ..... Future Years Defense Programs
GAO ..... United States General Accounting Office
GPS ..... Global Positioning System
ISR ..... Intelligence, Surveillance, Reconnaissance
JSOC ..... Joint Special Operations Command
LCC ..... Life Cycle Cost
MCA ..... Mission Capable Aircraft
MCS ..... Mission Capable Systems
MDT ..... Maintenance Downtime
MFPs ..... Major Force Programs
MTBM ..... Mean Time Between Maintenance
NAVSPECWARCOM ..... Naval Special Warfare Command
NCA ..... National Command Authority
O&M ..... Operations and Maintenance
O&S ..... Operation and Support
OLI ..... Operational Lethality Index
OOTW ..... Operations Other Than War
PA&E ..... Program Analysis and Evaluation
PE ..... Program Elements
PMO ..... Program Management Office
PPBS ..... Planning, Programming and Budgeting System
QDR ..... Quadrennial Defense Review
R&D ..... Research and Development
SDLM ..... Standard Depot Level Maintenance
SG&A ..... Selling, General and Administrative Cost
SII ..... Space, Information and Intelligence
SOAL ..... Special Operations Acquisition and Logistics Center
SOCS ..... Special Operations Command Support Center
SOFs ..... Special Operations Forces

SOIO ... Special Operations Intelligence and Information Operations Center
SOOP ..... Special Operations Operations, Plans, and Policy Center
SORR ..... Special Operations Requirements and Resources Center
TAT ..... Turn-around Time
TOA ..... Total Obligational Authority
TOC ..... Total Ownership Cost
TTC ..... Tail to Tooth Continuum
TTR ..... Tail to Tooth Ratio
USASOC ..... U.S. Army Special Operations Command
USCOMSOC ..... Commander, USSOCOM
USSOCOM ..... U.S. Special Operations Command

# ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to Professors John Mutty and Bill Gates for their assistance, guidance and professional wisdom throughout the process of developing this thesis.

To my husband, Errol thanks for your patience during this process. Hopefully, I will be able to return the favor next quarter. To the Velasco family …words cannot express the friendship you have provided me with over the last 18 months (and hopefully the coming years) - “Muchas Gracias.”

Tamara

My most profound gratitude goes to my loving wife, Monica, my sons Carlos A. and D. Felipe and my daughter M. Carolina, to whom my degree and this thesis owe a lot and I owe everything. To Tamara, it was an honor and a privilege working with you; the support and friendship you and Errol gave us is, by far, one of the things that made our experience at NPS and Monterey worthwhile.

Carlos

THIS PAGE INTENTIONALLY LEFT BLANK

# EXECUTIVE SUMMARY

The Tail-to-Tooth Ratio (TTR) expresses the relationship between the resources or forces employed to perform the core missions and the resources or infrastructure used to manage and support those forces. The Goldwater-Nichols Act of 1986 establishes a demarcation line between forces and infrastructure. The definitions of tooth and tail assumed by DoD from this law are, TOOTH: military units assigned to combatant commands, and TAIL: administration and force support activities assigned by the Secretary of Defense to the military departments, the Defense Agencies, civilian contractors or in some special cases combatant commands.

There are three different commonly accepted approaches to the definition of TTR:

1) A comparison of the dollars allocated to the combat or fighting capability (“tooth”), and the dollars allocated to everything else (“tail”). This approach in turn uses two methods to determine the TTR: the Force Structure vs. Infrastructure method and the Major Force Programs and Appropriation Codes method;

2) A comparison of the relationship between the people involved in combat and the people involved in support activities; and

3) A separate TTR for specific procurement programs or projects.

Due to the corporate world's focus on profits, it is easier to decipher what is "tooth" and what is "tail" within this environment than in DoD. However, even with this steady focus on profitability, disagreements still arise amongst business leaders regarding how this "tooth" and "tail" should be measured. Several methods are used, including absorption costing, variable costing, activity based costing and value chain analysis. Due to the intangible nature of DoD's bottom line, it has become increasingly more difficult to define the boundaries between "tooth" and "tail."

All of the methods used in DoD to measure the TTR attempt to establish an unambiguous boundary between "tail" and "tooth." Specific cases and examples confirm that such a clear-cut limit does not exist. On the contrary, the definitions of "tail" and "tooth" change with the specific situation, the environment and the timing of the measurement.

A new approach based on a new budgeting system, centered on outputs and outcomes instead of inputs, has several advantages such as its inherent focus on core competencies and core products, and the feasibility of evaluating the true costs of operations. However, it is not without weaknesses; its main weakness is that it is based on establishing a definite boundary between "tail" and "tooth" similar to the other methods.

Because the demarcation between "tail" and "tooth" is not fixed, their relationship should not be expressed as a ratio or a mathematical relationship between two numbers, but as a continuum. The "Tail to Tooth Continuum"

developed in this thesis was expanded to two and three dimensions, according to the activity's correlation with the core product, the current threat level in a specified type of conflict, and finally the relevance of the core product to the desired end result in explicit circumstances.

This approach does not imply that DoD, nor any other organization should neglect developing its core competencies. The advantage of this approach is that it avoids the fruitless labeling of costs, allowing management to concentrate on increasing efficiency and reducing the total costs of attaining DoD's desired outcomes.

THIS PAGE INTENTIONALLY LEFT BLANK

# I. INTRODUCTION

## A. PURPOSE

This research determines the key factors involved in calculating the Tail to Tooth Ratio (TTR); and analyzes the influence that the current top management intent on decreasing the TTR has had on the United States Department of Defense (DoD) operational readiness and expenditure efficiency (if such influence exists). DoD's top civilian management and the leaders of the uniformed services have expressed their commitment to reducing the "tail" in the TTR to alleviate the imbalance between infrastructure and force structure. However, a well-known management principle states that costs have to be understood and measured before they can be managed. Without a clear definition of "tail" and "tooth," it would be impossible to ascertain whether a reduction in the "tail" truly leads to increases in efficiency and readiness. As Sherlock Holmes said, "it is a capital mistake to theorize before one has data [Ref. 41, p. 57]." Therein resides the importance of this thesis.

The specific goal of this research is to provide DoD top management, Service leaders and acquisition program managers with a clearer understanding of the implications of the TTR, its value as a measure of operational readiness and military expenditure efficiency and the role it should play in determining budget appropriations.

## B. BACKGROUND

Over the centuries, organizations have looked for ways to measure effectiveness and efficiency. This has often been a difficult and laborious task. Competitive effectiveness is defined as the level of expected output actually achieved, while operating efficiency is related to how many resources were consumed to achieve the actual output. Often it is left up to the organization to decide what effectiveness and efficiency measures are appropriate.

DoD has widely used “Tail to Tooth Ratio” as an indicator of operating efficiency. It is used to measure the ratio between the dollars that are allocated to the combat capability (“tooth”) and the dollars that are allocated to everything else (“tail”). However, while the concept is widely accepted the specific definitions of “tail” and “tooth” are not. Each service within DoD has its own definition of what elements constitute “tail” and “tooth.” In recent years, the common perception throughout DoD is that the TTR is overly skewed towards the “tail;” both DoD and taxpayers view this as an inefficient use of funds.

## C. RESEARCH QUESTIONS

The primary research question of this thesis is: Is the TTR an appropriate measure of operational readiness and military expenditure efficiency? Secondary research questions are:

1. What elements should be considered “tail” or “tooth” in determining the TTR?

2. What factors have influenced the change of the TTR over the past centuries?

3. What is the effect of current technological advances on the TTR?

4. Is there a direct relationship between operational readiness and TTR?

5. Should DoD continue to pursue a reduction in the "tail" of all its programs?

## D. SCOPE

This thesis will include:

1. An in-depth examination of how the TTR is currently determined.

2. A comparative analysis of TTR calculations in DoD and in the corporate world.

3. The authors' opinion of what should be considered "tail" or "tooth" at the activity, program or program element level.

4. A description of how the TTR has changed over the centuries.

5. An analysis of how the current emphasis on unmanned vehicles/stand-off weapons may influence a specific program's TTR.

6. A study of the relationship between TTR and operational readiness for a specific program.

7. A review of current Department of the Navy (DoN) major cost reduction programs in relation to their impact on TTR.

## E. RESEARCH METHODOLOGY

The methodology used by the authors to complete this thesis research consisted of the following steps.

1. Literature search of books, magazine articles, journals, World Wide Web, DOD references, and other library information resources.

2. Review of applicable Policies, Norms and Regulations from DoD, JCS and the Service Chiefs.

3. Review of TTR calculations in different corporations.

4. Use of appropriate models to evaluate the impact of specific emergent technologies or logistic theories on the TTR of specified programs.

5. Review of current DoN major programs.

## F. THESIS ORGANIZATION

**Chapter I.** Introduction: identifies the purpose of this thesis and reviews the background as well as the primary and subsidiary research questions.

**Chapter II.** Determination of the Tail to Tooth Ratio: provides the reader with a basic understanding of the factors involved in determining the TTR and the current DoD norms and policies about calculating this ratio.

**Chapter III.** Historical perspective of the TTR: presents a historical perspective of how the TTR has changed over the centuries and an economic/financial interpretation of such changes.

**Chapter IV.** An analysis of the influence of technological advances in the TTR: analyzes the influence of some technological advances, like unmanned vehicles and stand-off weapons, on the life cycle costs of a program and on the breakdown between “tooth” and “tail” costs.

**Chapter V.** A study of the relationship between TTR and operational readiness: scrutinizes how the efficiency and

structure of the logistics chain influences the TTR and the relationship between TTR and operational readiness in a specified program.

**Chapter VI.** A comparative analysis within the corporate world: studies how the TTR is currently determined in the corporate world.

**Chapter VII**. A new approach to the TTR: analyzes the variations of the boundary between “tail” and “tooth” according to different circumstances, the possibility of integrating the corporate and DoD approaches to calculate the TTR to form a more accurate measure, and introduces a new concept for the definition of “tail” and “tooth.”

**Chapter VIII.** Conclusions and Recommendations: summarizes the research findings, answers the research questions and presents some areas of further research.

THIS PAGE INTENTIONALLY LEFT BLANK

# II. DETERMINATION OF THE TAIL TO TOOTH RATIO

## A. INTRODUCTION

This chapter describes the factors involved in determining the TTR and the current DoD processes and policies on the subject of calculating this ratio.

In general, the TTR expresses the relationship between the resources or forces employed to perform the core missions and the resources or infrastructure used to manage and support those forces. Defense experts normally refer to the "tail" as those non-combat activities and support services, which operate from fixed locations. However, as our analysis will show, this definition is still fuzzy; while the general concept of the TTR is apparently clear, the specific definitions of "tail" and "tooth" are not.

Not only are there several approaches to defining what elements constitute "tail" and "tooth," but there are also differences in the valuation variables of the actual TTR calculation, i.e. dollars, number of people, or number of systems. These differing viewpoints exist not only between non-DoD entities and DoD management, but also within each of the Services.

The Goldwater-Nichols Department of Defense Reorganization Act of 1986 addresses the separation of combat and support commands. The Act requires that the Secretaries of the military departments assign all forces under their jurisdiction to unified and specified combatant commands according to the force structure prescribed by the President. On the other hand, the military departments,

subject to the authority, direction, and control of the Secretary of Defense, are responsible for the activities that create, manage and support the forces assigned by them to a combatant command [Ref. 14, Chapter 6].

DoD has used the Goldwater-Nichols Act to establish a separation boundary between “tooth” and “tail.” “This feature of U.S. law provides the demarcation line between forces (military units assigned to combatant commanders) and infrastructure (activities retained by the military departments)” [Ref. 39, p. 184].

This chapter will show that the definitions of force structure and infrastructure used in the DoD and some U.S. Governmental and Non-Governmental agencies, are not always consistent with the Goldwater-Nichols Act, and in some cases the approaches are completely different.

## B. CURRENT PROCESSES/POLICIES REGARDING TAIL TO TOOTH RATIO MEASUREMENT

To arrive at a comprehensive list of the elements that constitute the “tail” and the “tooth,” the authors searched documents and publications from DoD, Congress, and diverse organizations. They examined concepts, testimonies, speeches, statements, and interviews released by top DoD management and Service leaders.

The goal was to integrate these policies and opinions into one single definition of TTR. The results of the search confirmed that there were three completely different approaches to the definition of TTR.

1) A comparison of the cost of the fighting forces versus the cost of support structures [Ref. 36, 39, 40];

2) A comparison of the relationship between the people involved in combat and the people in support activities [Ref. 36, 49]; and

3) A separate TTR for each specific procurement program or project [Ref. 48].

Instead of attempting to integrate these approaches into one single definition, the three methodologies are presented in detail in the following sections.

### 1. Cost of Fighting Forces Versus Support Structures

This approach measures the ratio between the dollars that are allocated to the combat or fighting capability ("tooth"), and the dollars that are allocated to everything else ("tail"). However, this definition has the same fundamental problem previously discussed, i.e. how to calculate the percentage of the budget that corresponds to "tooth" and what percentage corresponds to "tail." Two methods will be examined to determine the TTR: The Force Structure versus Infrastructure approach and the Major Force Programs and Appropriation Codes approach.

#### *a) Force Structure vs. Infrastructure Approach*

Section 118, Chapter 2, Title 10, of the United States Code (USC) mandates that every four years the Secretary of Defense shall: "conduct a comprehensive examination (to be known as a 'Quadrennial Defense Review (QDR)') of the national defense strategy, force structure, force modernization plans, infrastructure, budget plans, and other elements of the defense program and policies of the United States" [Ref.28: SEC. 901]. One of the aspects that must be included in the aforementioned report is:

> (8) The appropriate ratio of combat forces to support forces (commonly referred to as the 'tooth-to-tail' ratio) under the national defense strategy, including, in particular, the appropriate number and size of headquarters units and Defense Agencies for that purpose.

The definitions of force structure and infrastructure adopted by DoD are based on a Bottom-Up Review conducted in 1993 and a publication from the Institute for Defense Analyses titled ‘A Reference Manual for Defense Mission Categories, Infrastructure Categories, and Program Elements’ (originally prepared for the Office of the Secretary of Defense in 1991 and updated in 1995). These definitions were also used in the 1997 QDR and in subsequent Future Years Defense Programs (FYDP) [Ref. 40, Appendix L].

The 1997 QDR establishes a separation between **force structure** and **force infrastructure**, and equates the latter with support functions or “tail:”

> The DoD infrastructure includes a diverse set of activities… …among them are installations for the operating forces, training programs for military personnel, logistics support, central personnel services, and headquarters functions. In addition… medical care for active duty and retired military personnel and their family members, and… functions related to science and technology programs and central command, control, and communications services. [Ref. 36]

The 1997 QDR additionally sub-divides the infrastructure into Defense Agency/Defense-Wide infrastructure and Military Department infrastructure. The Defense Agency/Defense-Wide infrastructure is defined as those Defense agencies and defense-wide activities that carry out service and supply functions common to more than

one DoD component. Also encompassed are those centralized organizations and programs that provide services ranging from intelligence operations to commissaries, and from health care to research and development.

On the other hand, the Military Department infrastructure is comprised of resources and activities, such as resources for managing defense forces, facilities from which defense forces operate, non-unit training, and personnel support. The military department infrastructure also consists of acquisition support (including science and technology efforts as well as testing and evaluation) and C4I programs (command, control, communications, computer, and intelligence systems).

Although the basic definition of mission categories and infrastructure categories remain the same, the actual number of categories and the program elements that are assigned to each category have varied from year to year. As the role of the Armed Forces has changed over the years, the interpretation regarding which program elements in the FYDP should be associated with mission forces and which with infrastructure activities has changed accordingly.

The following tables, based on the Annual Reports to Congress and the President, illustrate the changes in DoD’s definitions of mission/force categories and infrastructure categories between 1995 and 2002.

**Table 2-1, Changes in the Force or Mission Categories**

| 1995 | 2002 |
|---|---|
| **Combat Forces**: programs associated with military combat units, such as heavy divisions, tactical aircraft squadrons, and aircraft carriers. | **Expeditionary Forces**: Operating forces designed primarily for non-nuclear operations outside the United States. Includes combat units (and their organic support) such as divisions, tactical aircraft squadrons, and aircraft carriers. |
| **Direct Support Forces**: programs associated with support units that deploy with combat forces, such as corps-level support, tanker aircraft squadrons, and naval replenishment ships. | |
| | **Homeland Defense**: Operating forces designed primarily to deter or defeat direct attacks on the United States and its territories. Also includes those agencies engaged in U.S. international policy activities under the direct supervision of the Office of the Secretary of Defense. |
| **Other Forces**: Includes most intelligence, space, and combat-related command, control, and communications (C3) programs, such as cryptologic activities, satellite communications, and airborne command posts. | **Other Forces**: Includes most intelligence, space, and combat-related command, control, and communications programs, such as cryptologic activities, satellite communications, and airborne command posts. |

[After Ref.40 Appendix L; Ref. 39, Appendix D, p. 184]

**Table 2-2, Changes in Infrastructure Categories**

| 1995 | 2002 |
|---|---|
| **Acquisition Infrastructure**: Program elements that support program management, program offices, and production support, including acquisition headquarters, science and technology, and test and evaluation resources. This category includes earlier levels of research and development, including basic research, exploratory development, and advanced development. | **Acquisition Infrastructure**: Activities that develop, test, evaluate, and manage the acquisition of military equipment and supporting systems. These activities also provide technical oversight throughout a system's useful life. |
| **C3 Infrastructure**: Programs that manage all aspects of the command, control, and communications infrastructure for DOD facilities, | **Communications and Information Infrastructure**: Programs that provide secure information distribution, processing, storage, |

| 1995 | 2002 |
| --- | --- |
| information support services, mapping and charting products, and security support. This category includes program elements that provide non-tactical telephone services, the General Defense Intelligence Program and cryptological activities, the Global Positioning System, and support of air traffic control facilities. | and display. Major elements include long-haul communications systems, base computing systems, Defense Enterprise Computing Centers and detachments, and information assurance programs. |
| **Central Logistics**: Programs that provide support to centrally managed logistics organizations, including the management of material, operation of supply systems, maintenance activities, material transportation, base operations and support, communications, and minor construction. This category also includes program elements that provide resources for commissaries and military exchange operations. | **Central Logistics**: Programs that provide supplies, depot-level maintenance of military equipment and supporting systems, transportation of material, and other products and services to customers throughout DoD. |
| **Central Medical**: Programs that furnish funding, equipment, and personnel that provide medical care to active military personnel, dependents, and retirees. Activities provide for all patient care, except for that provided by medical units that are part of direct support units. Activities include medical training, management of the medical system, and support of medical installations. | **Defense Health Program (DHP)**: Medical infrastructure and systems, managed by the Assistant Secretary of Defense for Health Affairs, that provide health care to military personnel, dependents, and retirees. |
| **Central Personnel:** All programs that provide for the recruiting of new personnel and the management and support of dependent schools, community, youth, and family centers, and child development activities. Other programs supporting personnel include permanent change of station costs, personnel in transit, civilian disability compensation, veterans | **Central Personnel Administration**: Programs that acquire and administer the DoD workforce. Includes acquisition of new DoD personnel, station assignments, provision of the appropriate number of skilled people for each career field, and miscellaneous personnel management support functions, such as personnel transient and holding accounts. |

| 1995 | 2002 |
|---|---|
| disability compensation, veterans education assistance, and other miscellaneous personnel support activities. | **Central Personnel Benefits Programs**: Programs that provide benefits to service members. Includes family housing programs; commissaries and military exchanges; dependent schools in the United States and abroad; community, youth, and family centers; child development activities; off-duty and voluntary education programs; and a variety of ceremonial and morale-boosting activities. |
| **Central Training**: consists of program elements that provide resources for virtually all non-unit training, including training for new personnel, aviation and flight training, military academies, officer training corps, other college commissioning programs, and officer and enlisted training schools. | **Central Training**: Programs that provide formal training to personnel at central locations away from their duty stations (non-unit training). Includes training of new personnel, officer training and service academies, aviation and flight training, and military professional and skill training. Also includes miscellaneous other training-related support functions. |
| **Force Management**: consists of all programs that provide funding, equipment, and personnel for the management and operation of all the major military command headquarters activities. Force management also includes program elements that provide resources for defense-wide departmental headquarters, management of international programs, support to other defense organizations and federal government agencies, security investigative services, public affairs activities, and criminal and judicial activities. | **Departmental Management**: Headquarters whose primary mission is to manage the overall programs and operations of the DoD and its components. Includes administrative, force, and international management headquarters, and defense-wide support activities that are centrally managed. Excludes headquarters elements exercising operational command (which are assigned to the Other Forces category) and those management headquarters that are associated with other infrastructure categories. |
| **Installation Support**: consists of activities that furnish funding, equipment, and personnel to provide facilities from which defense forces operate. Activities include construction planning and design, real property maintenance, base operating support, real estate management for active and reserve bases, family housing and bachelor housing, supply operations, base | **Force Installations**: Installations at which combat units are based. Includes the services and organizations at these installations necessary to house and sustain the units and support their daily operations. Also includes programs to sustain, restore, and modernize buildings at the installations and protect the environment. |

| 1995 | 2002 |
|---|---|
| closure activities, and environmental programs. | |
| | **Other Infrastructure**: These programs do not fit well into other categories. They include programs that (1) provide management, basing, and operating support for DoD intelligence activities; (2) conduct navigation, meteorological, and oceanographic activities; (3) manage and upgrade DoD-operated air traffic control activities; (4) support warfighting, wargaming, battle centers, and major modeling and simulation programs; (5) conduct medical contingency preparedness activities not part of the DHP; and (6) fund CINC-sponsored or JCS-directed joint exercises. Also included in this category are centralized resource adjustments that are not allocated among the programs affected (e.g., foreign currency fluctuations, commissary resale stocks, and force structure deviations). |
| | **Science and Technology Program**: The program of scientific research and experimentation within the DoD that seeks to advance fundamental science relevant to military needs and determine if the results can be successfully applied to military use. |

[After Ref.39, Appendix D, pp. 184,185; Ref.46; Ref.52, Appendix II, pp. 47,48]

In summary, force structure is associated with components directly related to mission, i.e. aircraft squadrons, ships, weapons, infantry units, etc. Force infrastructure is related to activities that provide services to mission programs and operate mainly from fixed locations i.e. payroll, training, recruiting, travel, education, data processing, staff, military construction, housing, inventory management, transportation, depot maintenance, etc. When force allocations are reduced there

is a direct effect on mission accomplishment and capability. When infrastructure allocations are reduced there may be a direct or indirect effect on mission effectiveness [Ref.46].

### *b) Major Force Programs and Program Elements (PE)*

The concept of TTR is also associated with the Major Force Programs (MFPs) and Program Elements (PE).

There are 11 MFPs created as a measurement and control system for the Defense Budget. They allow the establishment of prioritized objectives (needed capabilities) and the measurement of the progress towards those objectives, while matching defense missions (outputs) with defense resources (inputs). The initial objective of the MFPs was to increase the supervision of the budget by producing a number of common categories of defense programs, which crossed Service lines (Figure 2-1). Each MFP contained the resources needed to achieve an objective or plan, but each service controlled the portion of the MFPs relating to their particular mission [Ref. 49, p. 42, 79], [Ref. 23, p. 6].

The initial MFPs were instituted in 1961 and were clearly related to the principal missions the Armed Forces needed to perform [Ref. 23, p. 4]. However, contrary to the recent modifications and additions made to the Mission and Infrastructure Categories shown in Table 2-1 and Table 2-2, the only “major” change to the MFPs since their introduction was adding the Special Operations Forces Program in 1987, mandated by the Cohen-Nunn amendment to the DoD Reorganization Act.

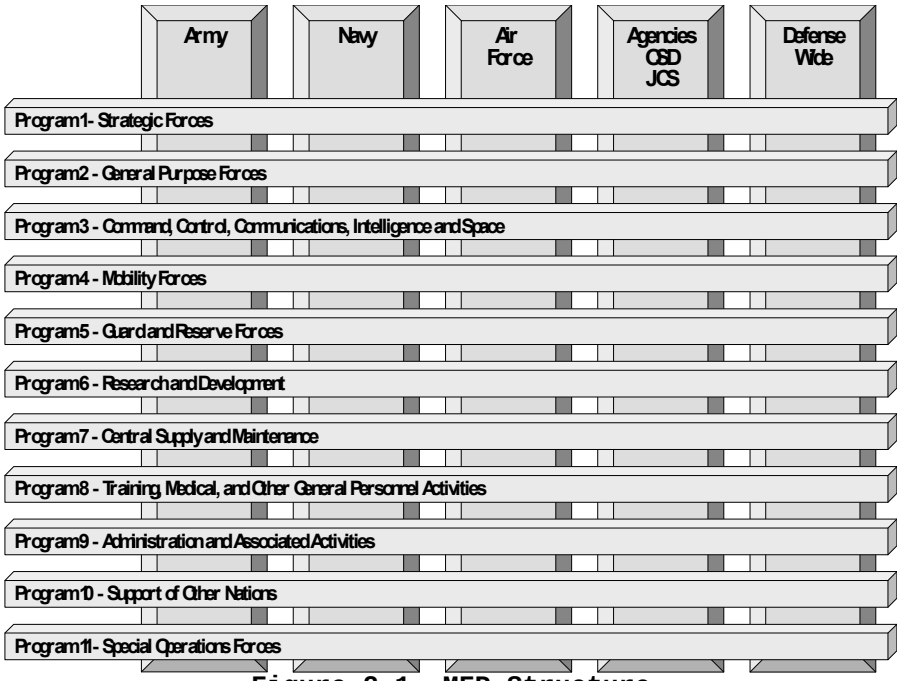


**Figure 2-1, MFP Structure**
**(From Ref. 23, p. 6)**

Each MFP specifies a mix of capabilities and contains numerous systems performing specific missions; these building blocks are referred to as Program Elements (PEs). Each PE represents a mission or a support function of a Joint Program, Service, or Defense Agency. A PE documents all the resources necessary to complete a program, such as forces (development, construction, procurement or operation of ships, planes, tanks, etc), manpower (military or civilian) and dollars (Total Obligational Authority (TOA)). There are approximately 5,000 to 6,000 PEs, most of which belong to the Services [Ref. 49, p. 41], [Ref. 29].

The following are the definitions of the Major Force Programs as stated by the Naval Postgraduate School (NPS) Web based course “Financial Management in the Armed Forces.”

(1) Strategic Forces: this program includes those forces, offensive or defensive, whose missions encompass intercontinental or transoceanic inter-theater responsibilities. It contains the operational management headquarters, the intelligence and communications functions, logistics, and support organizations identifiable and associated with the program or mission.

(2) General Purpose Forces: forces whose mission responsibilities are, at a given point in time, limited to one theater of operation. This program includes command, logistics, intelligence and communications organizations/functions associated or organic to these forces; and the related support units that are deployed as a constituent part of these organizations. This program also comprises other sub-programs, such as JCS-directed and coordinated exercises, Coast Guard ship support program, war reserve material, ammunition, and equipment.

(3) Command, Control, Communications, Intelligence and Space: comprises intelligence, security, communications and functions, such as mapping, charting, and geodesy activities, weather service, oceanography, special activities, nuclear weapons operations, space boosters, satellite control and aerial targets. As mentioned in previous programs, the intelligence and communications functions that are specifically identifiable to a mission shall be included within the appropriate program.

(4) Mobility Forces: comprises airlift, sealift, traffic management, and water terminal activities, both direct-funded and through the Defense Working Capital

Fund (DWCF), including command, logistics, and support units organic to these forces.

(5) Guard and Reserve Forces: consists mainly of Guard and Reserve training units in support of strategic, offensive, defensive and general purpose forces. There are also units that support intelligence and communications; space; airlift and sealift; research and development; central supply and maintenance; training, medical, general personnel activities, administration, and assistance to other nations.

(6) Research and Development: comprises all research and development programs and activities that have not yet been approved for operational use. It includes basic and applied research tasks and development; and test and evaluation of new weapons systems equipment and related programs.

(7) Central Supply and Maintenance: this program includes resources related to supply, maintenance, and service functions or activities necessary to fulfill DoD programs, both direct-funded and through the DWCF, such as first and second destination transportation, overseas port units, industrial preparedness, commissaries, logistics and maintenance support, depot maintenance and supply management. These functions are usually centrally managed.

(8) Training, Medical, and Other General Personnel Activities: comprises resources, functions and activities related to training and education, personnel procurement services, health care, permanent change of station (PCS) travel, transients, family housing, and other support activities associated with personnel. The

functions and activities in this program are mainly centrally managed.

Excluded from this program are:

(a) Training specifically related to and identified with another major organic program.

(b) Housing subsistence, health care, recreation, and similar costs and resources, such as base operations, which are organic to a program element and are included in other major programs.

(9) Administration and Associated Activities: comprises resources for the administrative support of departmental and major administrative headquarters, field commands, and administration and associated activities not specifically identifiable to a mission in any of the other major programs. Included in this program are activities such as construction planning and design, public affairs, contingencies, claims, and criminal investigations.

(10) Support of Other Nations: resources in support of international activities, including the Military Assistance Program (MAP), Foreign Military Sales (FMS), the North Atlantic Treaty Organization (NATO) infrastructure, and humanitarian assistance.

(11) Special Operations Forces: comprises force-oriented special operations forces (Active, Guard and Reserve), including the command organizations and support units directly related to these forces.

The above approach further illustrates the various interpretations of tooth and tail within DoD. For example, the NPS Web based course [Ref. 29] considers

programs 1 through 5 and 11 as “combat forces programs” or tooth, while the U.S. Commission on National Security considers that only programs 1, 2 and 11 are military “forces” or tooth. [Ref. 49, p. 79] All other programs are considered “defense support activities.”

When this method is used, it is assumed that all PEs within each MFP are homogeneous. For example, if the MFP is considered a “tooth” program then the PEs contained within this program are also “tooth.”

**2. TTR Relationship to Combat and Support Personnel**

While most definitions of TTR are based on dollar amounts, some approaches only take into account the number of military personnel (Soldiers, Sailors and Marines) assigned to actual combat positions vs. the rest of the members of DoD, or in other words the ratio of combat manpower to support manpower.

Regarding the “tooth to tail ratio,” the 1997’s QDR expressed:

> The organizations that performed [infrastructure] functions accounted for 48 percent of total DoD employment (military and civilian) in FY 1997. In addition, 7 percent of DoD employees provide medical care for active duty and retired military personnel and their family members, and another 6 percent perform functions related to science and technology programs and central command, control, and communications services. In sum, 61 percent of people employed by the Department in FY 1997 are performing infrastructure functions. [Ref. 36]

Other studies present a much worse situation. For example, according to the U.S. Commission on National Security:

> DoD's "tail-to-tooth" ratio is too large by any measure. Nearly 30 "division-equivalents" of support personnel (approximately 450,000 people) perform service and support functions similar to jobs in the civilian sector. The sharp end of the spear, the "teeth"… … constitutes barely 200,000 warfighters out of DoD's 2.0 million full-time military and civilian personnel. That means that there are almost four DoD civilians for every uniformed soldier, sailor, airman, or marine in the active combat units. There are also nearly five uniformed military personnel in the "tail" for every individual assigned combat duty. [Ref. 49, p. 20].

As with the infrastructure and MFP approaches, the personnel approach also shows various methods of interpretation, leading to variances in the calculation of the TTR; hence, the variability in the definition of TTR.

### 3. Procurement Programs and Projects

The third approach is to define a separate TTR for each specific procurement program and project. For example, besides the acquisition or unit cost (the "tooth"), each platform or weapon system carries with it several other costs (the "tail"). These costs consist of the operating crew, the maintenance crew, training, and infrastructure and logistics support. The "tail" cost per unit is determined by dividing the total cost of the "tail" items within the program by the number of units acquired.

A memorandum from the Under Secretary of Defense (Acquisition and Technology) states:

> Defense Systems Total Ownership Cost (TOC) is defined as Life Cycle Cost (LCC). LCC (per DoD 5000.4M) includes not only acquisition program direct costs, but also the indirect costs attributable to the acquisition program (i.e., costs that would not occur if the program did not

exist). For example, indirect costs would include the infrastructure that plans, manages, and executes a program over its full life and common support items and systems. [Ref. 48]

This approach is conceptually different than the ones previously discussed, because anything that is not a part of the equipment acquisition cost is considered tail. Even the military personnel whose jobs it will be to employ the system in combat missions are regarded as tail. This methodology is closely related to the Total Ownership Cost (TOC) approach.

In the TOC approach, the tail combines all elements that represent the total logistics burden of a system on a tactical unit in the field/fleet; including facilities, training, fuel & ammo consumption, manpower requirements, publications, preventative & corrective maintenance, support equipment, etc. Some of these costs are determined by design early in the acquisition cycle and some of these costs can be managed in the field/fleet.

All these post-deployment operations and support costs normally represent 65% to 80% of the system LCC or TOC. [Ref. 24]

## C. CURRENT TTR IN THE DEPARTMENT OF DEFENSE

### 1. Calculation Using the Force Structure vs. Force Infrastructure Approach

As discussed in section II.B.1.a), this is the approach employed by DoD in the Annual Reports to Congress and the President. The following graph (Figure 2-2) and Table A - 1 Appendix A are based on the Annual Report of 2002 [Ref. 39, Table D-1]. These references show the

variations of the force infrastructure categories from 1998 to 2002 (in percentages and in FY 2003 $Billions). Figure 2-2 is a percentage stacked line graph. It also presents the four components of force structure stacked above the force infrastructure to complete the TOA for each of those years.

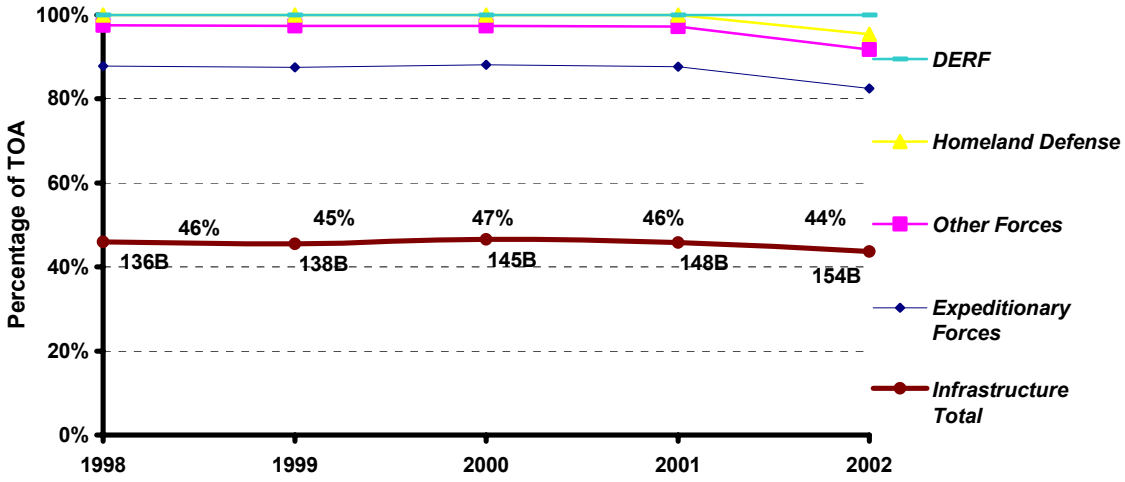


**Figure 2-2, Variations in Force Structure and Force Infrastructure Categories**

As Figure 2-2 shows, the portions of the budget associated either with mission or with support activities have remained relatively constant in the last five years. However, the graph shows that a redistribution of the budget is taking place within the Force Structure categories, and the Defense Emergency Response Fund (DERF) is absorbing a significant percentage of the force structure appropriations.

According to the United States General Accounting Office (GAO), this approach does not account for all DoD infrastructure related programs:

> There are parts of the total infrastructure funding that cannot be clearly identified in the FYDP, according to DOD officials. These funds pay for goods and services sold by the Defense

> Business Operations Fund (DBOF) activities. The officials estimate that this is about 20 to 25% of DOD's total infrastructure and mostly represents logistics purchases, which cannot be specifically identified [Ref. 52, p.3]

The difficulty in identifying all infrastructure funding results from the fact that some agencies or activities derive a portion of their funding from the goods and services they sell to other DoD programs. As a result, some infrastructure costs are included in defense activities' budgets that are normally considered as force programs [Ref. 52, pp. 3-6]. This situation is common for activities that are a part of the Defense Working Capital Fund (DWCF) (formerly known as DBOF).

The amount of the force programs' budgets that resulted in infrastructure costs for the fiscal year 1995 FYDP (1995- 1999), was estimated by the Office of Program Analysis and Evaluation (PA&E) to be between $28 and $39 billion in FY1996 dollars [Ref. 52, p. 4]. If this estimate is valid, the costs of infrastructure as shown in Figure 2-2, are understated and only represent about 75 % of the total infrastructure funding (this is the approach followed by the GAO).

More recent estimates show that the total orders generated from DoD components which provide funding for the DWCF budget actually oscillate between $20.5 and $21 billion in FY 2003 dollars (see Table A - 4, Appendix A). This represents a drastic reduction from the GAO estimates. With these values, the costs of infrastructure displayed in Figure 2-2 actually represent approximately 86% of the real infrastructure funding. Furthermore, the budget of the DWCF

originates from orders from “all” DoD components and not only from “force” components. Subsequently, a more suitable approach would be to allocate the DWCF costs between the forces and infrastructure components according to their respective weight in the total budget.

Figure 2-3 shows the variations in the infrastructure costs as a percentage of the TOA. The lowest line corresponds to the total infrastructure values shown in Figure 2-2. The second line from the bottom shows the infrastructure when the DWCF costs are allocated (or divided) between forces and infrastructure. The third line shows that the infrastructure costs would represent 50% to 53% of TOA, if the concept that all DWCF costs have their origin only in force programs is presumed valid. The last line reflects that the costs of infrastructure vary from 57% to 61% of the TOA if the GAO approach is used.

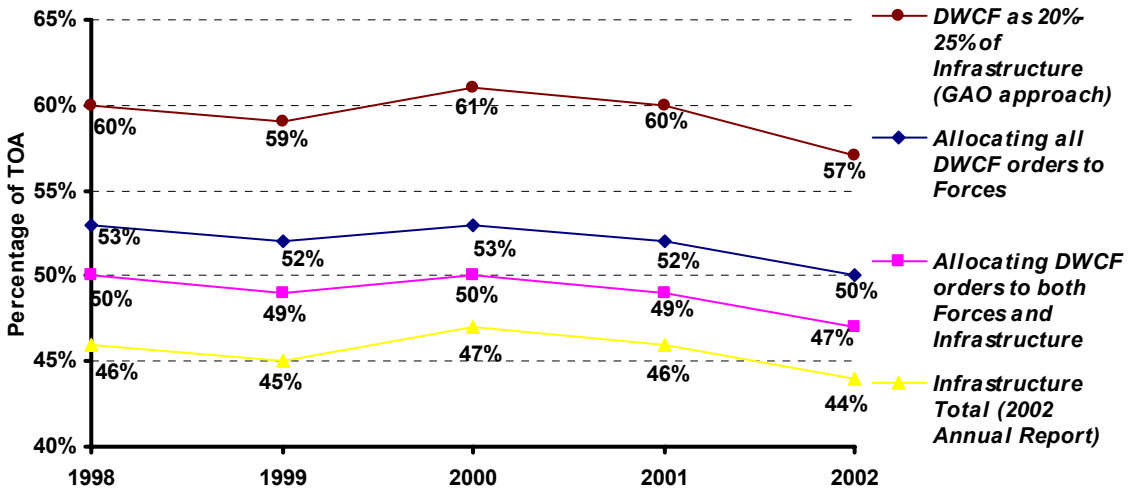


**Figure 2-3, Variations in Infrastructure According to the Allocation of DWCF**

Finally, Figure 2-4 and Figure 2-5 show the year to year percentage increase (or reduction) of the TOA, force structure categories and total force infrastructure. With

the exception of the transition from FY1999 to FY2000, the total appropriation to "forces categories" has consistently grown at a higher rate than the total appropriations to "infrastructure categories." The fastest growing force structure categories are Homeland Defense Forces and the DERF (not shown in Figure 2-5 because the increment from FY2001 to FY2002 is infinite). On the contrary, the "Other Forces" category decreased by 3% between FY1999 and FY2000.

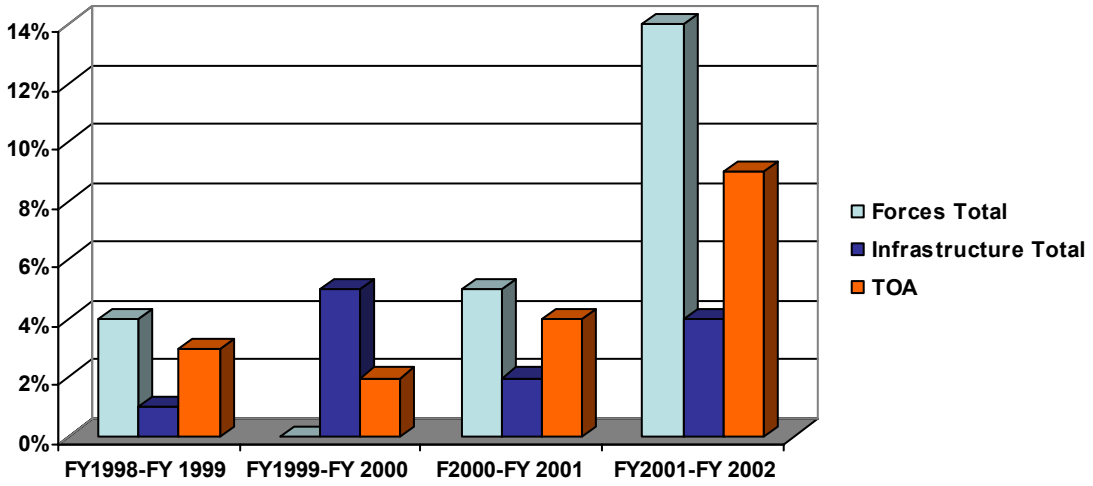


**Figure 2-4, Percentage Yearly Variation in the Budget**

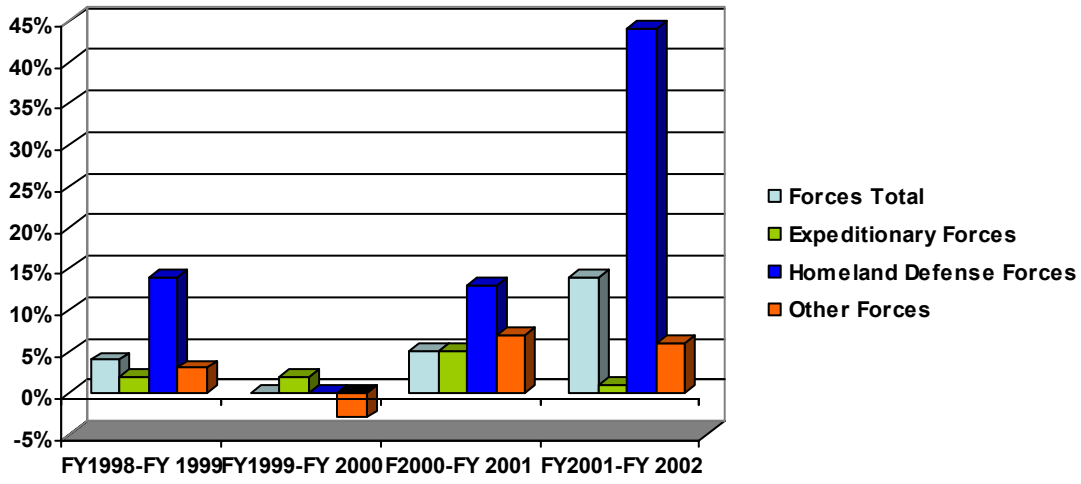


**Figure 2-5, Percentage Yearly Variation in the "Force Categories" Budget**

### 2. Calculation Using MFPs Approach

Section II.B.1.b) defined a MFP as an aggregation of PEs that reflects a DoD force mission or support mission. Consequently, DOD uses the Major Force Programs approach to appraise the allocation of funds between “infrastructure” and “forces.” However, current MFPs in the Planning, Programming and Budgeting System (PPBS) do not offer a useful base for this type of analysis nor do they offer a clear distinction between activities that are truly “forces” and activities that are “combat support” or “service support.” Some studies also state that most PEs are outdated and many are assigned to the wrong MFPs with the result that meaningful analyses across MFPs are difficult, and often misleading. [Ref. 49, p. 41]

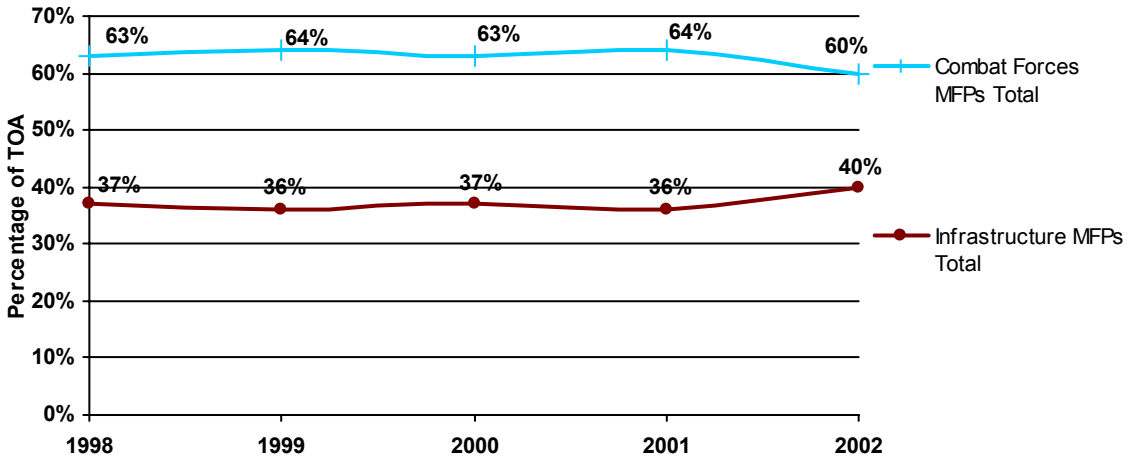


**Figure 2-6, Combat Forces MFPs Vs. Infrastructure MFPs**

As was also mentioned in section II.B.1.b), some approaches consider programs 1 through 5 and 11 as “combat forces programs.” If those approaches are accepted, then the “infrastructure” programs will amount to approximately 36% to 40% of TOA for FY1998 to FY2002 as shown in Figure 2-6 and Table A - 2, Appendix A. Figure 2-7 shows the

budget appropriation distribution within these 6 MFPs considered by several sources as “combat forces programs.”

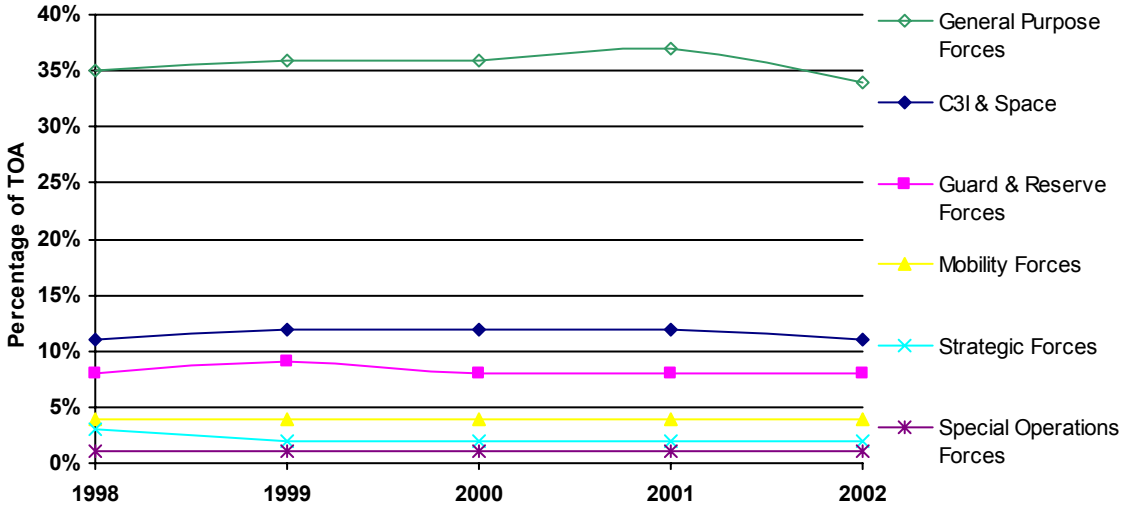


**Figure 2-7, Appropriation Distribution within Combat Forces MFPs**

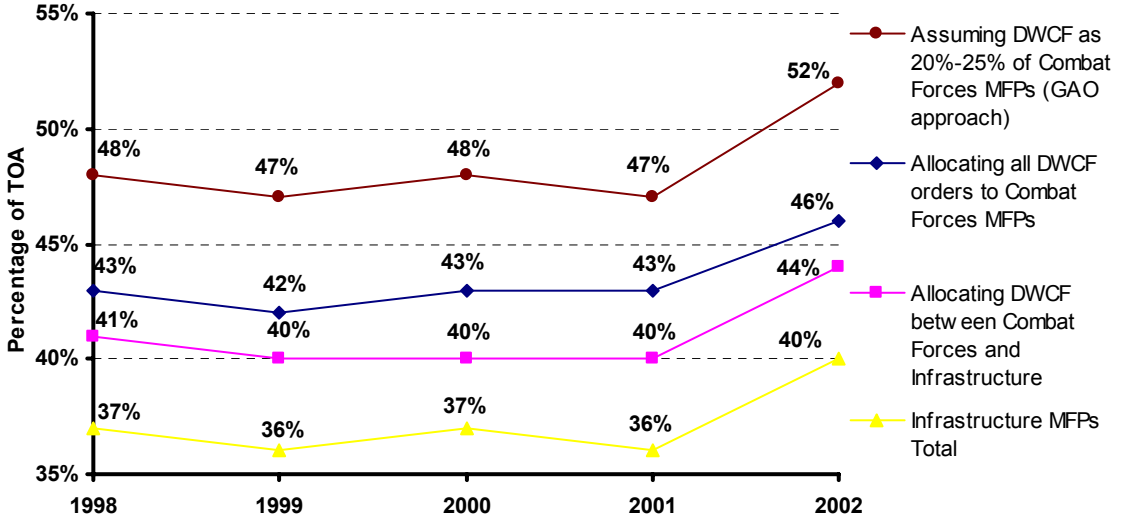


**Figure 2-8, Variations in Infrastructure According to the Allocation of DWCF Between the MFPs**

The argument presented in the last section about some agencies deriving a portion of their funding from the goods and services they sell to other DoD programs is also valid here. In this case, some infrastructure costs can be included in MFPs normally considered as “combat forces

programs." The method used to allocate the DWCF between the "combat force programs" and the "defense support activities" will influence the total amount of the budget that is considered "infrastructure." Figure 2-8 shows that "Total Infrastructure" can vary up to 12% depending on the method used to allocate the orders from DoD Components to the DWCF.

Applying the concept that only three (Strategic, General Purpose and Special Operation Forces) of the current eleven MFPs focus on military "forces," while the remainder include defense support activities, changes drastically the relationship between "forces" and "infrastructure." Figure 2-9 and Table A - 1, Appendix A show that approximately 60% to 62% of the budget would be assigned to infrastructure programs.

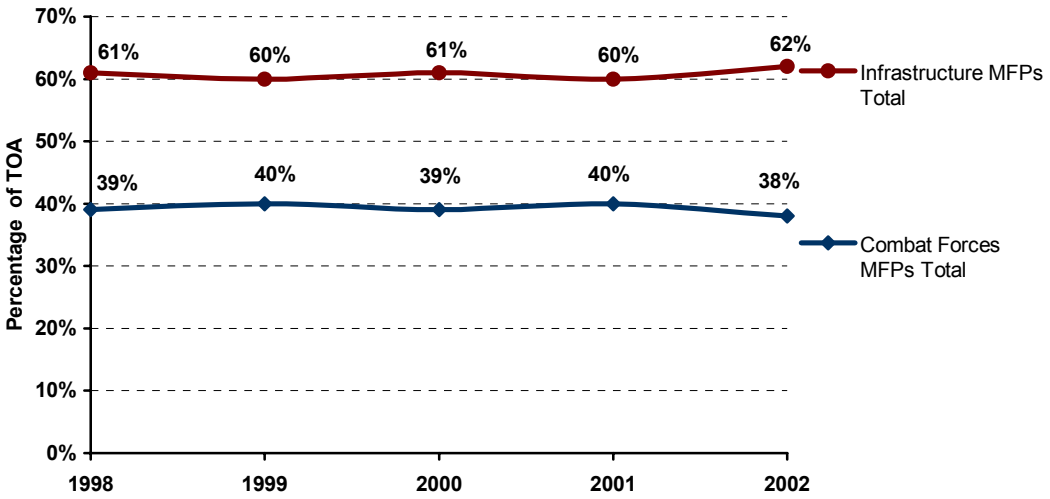


**Figure 2-9, Combat Forces MFPs Vs. Infrastructure MFPs**

Figure 2-10 shows the budget appropriation distribution within the 3 MFPs considered as "combat forces programs" in this case.

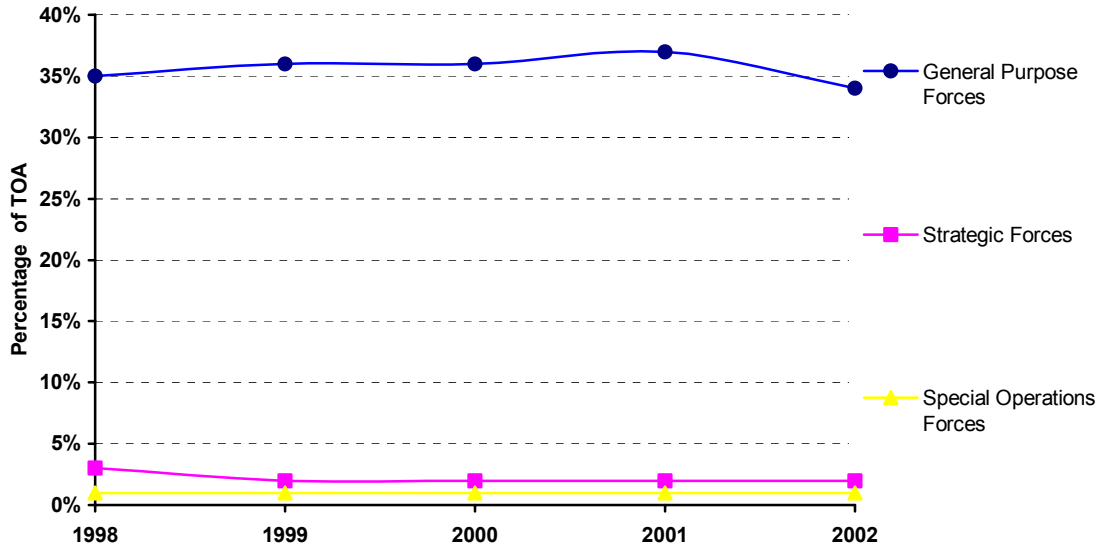


**Figure 2-10, Appropriation Distribution within Combat Forces MFPs**

The same analysis of the past sections for the allocation of the orders from DoD Components to the DWCF applies in this case. Figure 2-11 shows that now the percentage of the budget that could be considered infrastructure may be as high as 81%.

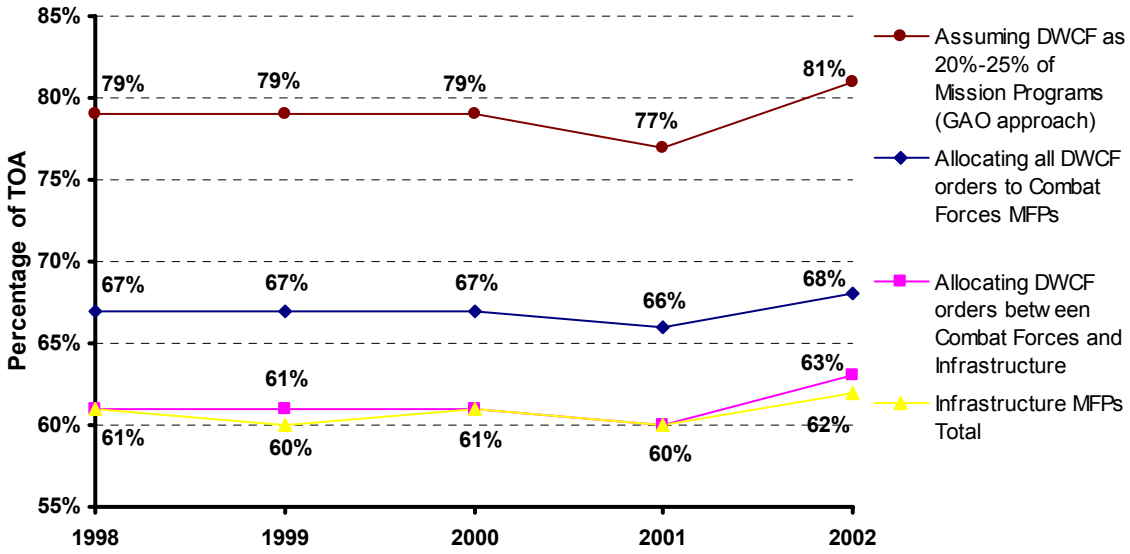


**Figure 2-11, Variations in Infrastructure According to the Allocation of DWCF Between the MFPs**

### 3. Calculation Using Personnel Approach

The current DoD approach for measuring the ratio of combat manpower to support manpower uses the same force and infrastructure categories from the FYDP described in section II.B.1.a), Table 2-1 and Table 2-2 [Ref. 40, Table D-2]. Figure 2-12 and Table A - 5, Appendix A show the variation of this ratio for the Active-Duty Military and Civilian personnel in the last five years (excluding Reserve and National Guard).

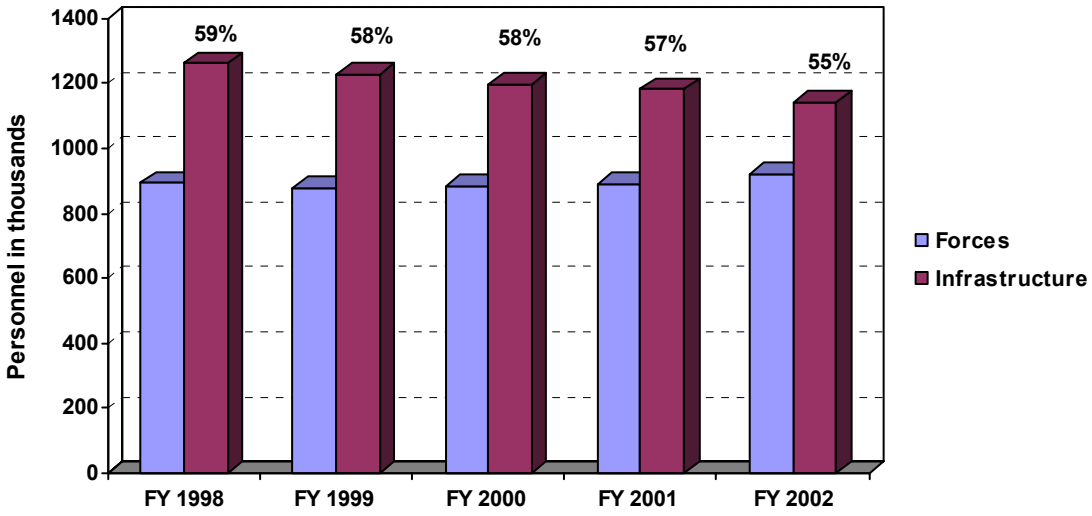


**Figure 2-12, Combat Manpower vs. Support Manpower**

Using the same force and infrastructure categories mentioned above, Figure 2-13 further specifies the ratio of combat manpower to support manpower for each of the Services, Defense Agencies and Defense-Wide personnel. As expected, most personnel in Defense-Agencies and Defense Wide activities are considered “tail.” On the other hand, between 50% to 55% of the members of the Marine Corps and the Army are regarded as “tooth.” The Navy and the Air

Force are located in an intermediate position with a personnel "tail" of around 55% to 65%.

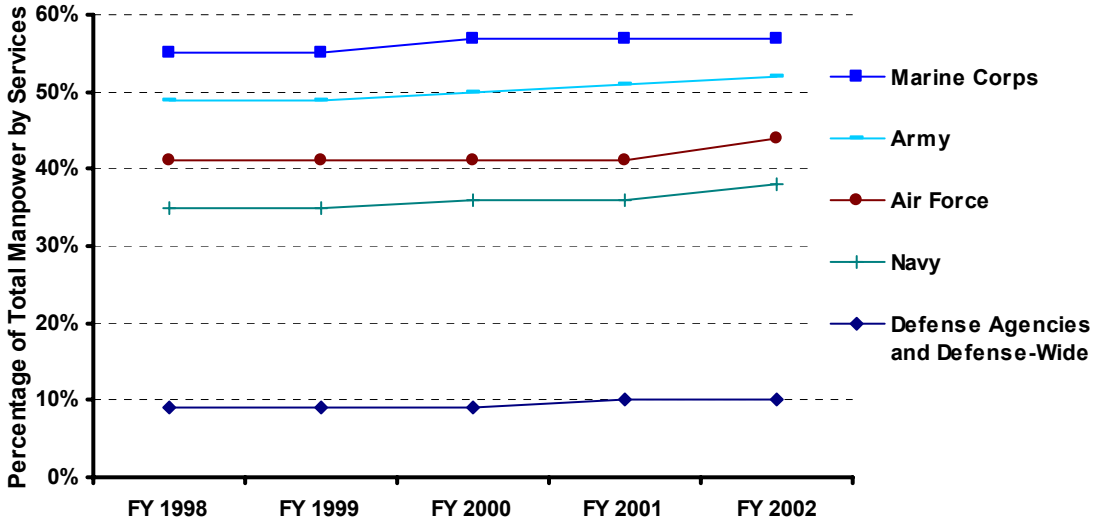


**Figure 2-13, Ratio of Combat Manpower to Total Manpower by Services**

Not all analyses agree with these numbers. According to the GAO, "DOD may not be accurately accounting for all personnel assigned to OSD. Some personnel temporarily assigned to OSD by other DOD components are functioning more as permanent staff and are not being reported as OSD personnel." [Ref. 53, p.3] The GAO also reported that there are inconsistencies amongst the service components in the type of positions that are designated as headquarters [Ref. 54, p. 12]. The US Commission on National Security/21st Century also acknowledges DoD headquarters are larger than advertised, because of billets and duties "hidden" within other agencies [Ref. 49, p. 14]. In general, DoD concurs with these claims; the Defense Reform Initiative contains decisions to solve most of these problems [Ref. 53, pp. 18, 19].

### 4. Advantages and Disadvantages of Each Method

There are many advantages and disadvantages to each approach. This makes it inherently difficult for the different agencies to agree on a “standard” approach to determining TTR. The following is a list of the advantages and disadvantages of the three approaches:

Cost of fighting forces versus support structures: an advantage of this approach is that PEs can be employed in both the Force Structure vs. Infrastructure and the Major Force Programs and Program Elements methods to determine TTR. This approach also has technical feasibility; the information can be monitored and measured easily by an IT system. However, in the first method the additional costs of defining and maintaining MFPs as well as categories of forces and infrastructure may become people intensive and hence cost prohibitive. Another disadvantage is that these approaches assume the PEs are homogenous, if this assumption is incorrect then some method has to be employed to breakdown the PEs into forces and infrastructure; this leaves the breakdown to the subjectivity of the specific agencies. The biggest disadvantage in the second method is that there are many gray zones (some MFPs are comprised of both tail and tooth elements) in the classification of the MFPs.

TTR relationship to combat and support personnel: this approach assumes that number of personnel is the cost driver for both tooth and tail. This approach is easier and costs less to measure. However, this assumption might be too simplistic and leaves out other key aspects. Another

major disadvantage is the cost associated with defining and maintaining categories of force and infrastructure.

Procurement Programs and Projects: with a good analysis tool (simulation) this approach can clearly identify cause and effect relationships and manage them in order to reduce costs. There is already a pre-existing infrastructure within Program Offices (Program Managers) to measure these costs. However, this approach only takes into account the costs of existing programs, it does not take into account the general and administrative costs associated with the non-combatant commands.

## D. CHAPTER SUMMARY

This chapter analyzed the main factors involved in calculating the TTR. The Goldwater-Nichols Act established a demarcation line between forces and infrastructure. The definitions of tooth and tail as assumed by DoD from this law are, TOOTH: military units assigned to combatant commands, and TAIL: administration and force support activities assigned by the Secretary of Defense to the military departments, the Defense Agencies, civilian contractors or in some especial cases combatant commands.

Three different approaches to the definition of TTR were presented and the current TTR in DoD was calculated using the first two approaches, (the third approach will not provide a total TTR for DoD, and can only be calculated on a case by case basis for each acquisition program):

1) Comparing the dollars that are allocated to the combat or fighting capability (tooth), and the dollars that are allocated to everything else (tail). Within this

approach two methods to determine the TTR were examined: the Force Structure vs. Infrastructure method and the Major Force Programs and Appropriation Codes method;

2) Comparing the relationship between the people involved in combat and the people involved in support activities; and

3) A separate TTR for specific procurement programs or projects.

Finally the advantages and disadvantages of each of the three methods were discussed.

# III. HISTORICAL PERSPECTIVE OF THE TTR

## A. INTRODUCTION

Military historians have recognized the importance of logistics and supply lines for centuries. For example, regarding the command needs, T'ai Kung in his Six Secret Teachings (eleventh century B.C.) recommended the number of aides to dedicate to logistics: "Supply officers, four: responsible for calculating the requirements for food and water; preparing the food stocks and supplies and transporting the provisions along the route; and supplying the five grains so as to ensure that the army will not suffer any hardship or shortage [Ref. 38, pp. 60, 61]." Interestingly, T'ai Kung used many animal body parts to describe the jobs of the General's assistants: 'legs and arms' (direct staff), 'ears and eyes' (intelligence), 'claws and teeth' (moral and martial law officers), 'feathers and wings' (image and propaganda); but apparently 'tail' was never used.

Sun-Tzu's Art of War (written approximately in the sixth century B.C. and generally considered the oldest and greatest known Chinese military work), also presents logistics and provisions as one of the basic elements for mobilization and for obtaining the advantages of military actions [Ref. 38, p. 159].

Most military history books however, only present the strategic and tactical aspects of the battles and pay little or no attention to how the commanders logistically supported the forces involved in the struggle. The lack of

logistics details makes it appear as if the commanders were able to move entire armies (forces and resources) effortlessly toward their objectives [Ref. 37, p. 1].

This chapter presents a historical perspective of how logistic needs have shaped the TTR of armies over the centuries. It is virtually impossible to obtain reliable financial data from more than a few decades ago. Due to this constraint, most of the analysis in this chapter regarding the TTR will use the “combat vs. support personnel” approach.

Low technology, manpower intensive armies (such as ancient armies) can employ the personnel approach with a certain degree of confidence. In early times, “support forces” always traveled with the army, for this reason some sections of this chapter will regard all support personnel as tail regardless of their geographical location (i.e. detached with the forces vs. operating from a fixed location).

This chapter is significant because knowledge of the past enhances the perception and ability to understand the present; this is especially true within the military.

## B. ANCIENT MILITARY TRENDS

Throughout history there is abundant evidence that the development of mankind and warfare are inextricably tied together. Ancient history records are largely dedicated to wars and conquests. The literature presents many examples of the simultaneous development of utensils for hunting, household and weaponry; first using stone and later metal. As time progressed trends can be seen towards introducing

the military transport; increasing the ascendancy of the horseman; and upgrading manufacture “technology” for primitive weapons. At that moment, in addition to the weapons and the mission, the capabilities for transporting and supporting the warriors began to dictate the composition and tactics of each army [Ref. 8, p. 1-3].

Prior to 1000 B.C. armies were organized according to specific social structures. The nobles and members of the royal family rode in chariots. The cavalry was composed of lesser nobles and the infantry was made up of men from the poorest social classes. There was very little organization and no prearranged campaigns; battles were conducted similar to a modern day raid. [Ref. 8, p. 3, 4]

The TTR of these armies was expectedly very low based on their tactics and socio-economic breakdown. The nobles that comprised the cavalry sections were expected to supply themselves with horses, weapons, armor and other goods. The infantry soldiers were expected to obtain their supplies through loot and booty. There was no need for care or supplies for prisoners because defeated armies were slaughtered. Captured cities were destroyed and the people enslaved to support the armies’ needs [Ref. 8, p. 3, 4]. With this type of socio-economic structure and concept of warfare, there was very little need for organic support personnel other than the nobles’ servants and possibly a staff for the general (normally the King).

## C. EARLY MILITARY SOCIETIES

Around 700 B.C., war became the main business of many nations. The need for increasing wealth was satisfied

mainly through the proceeds of armed combat. Military and political organizations began to consolidate and blend. Regular armies were created and the states, including their financial and administrative systems, were built around those armies. This military nature of the state extended well into the Roman Republic and even to the feudal era in the years 800 to 1000 A.D. A combination of civil and military authority on the general's staff facilitated the administration and the logistics support of the armies. [Ref. 2]

There are no clear records to determine an exact TTR. However, information about the field armies of these ancient military organizations maintains that they may have occasionally approached 100,000 men and that these armies were accompanied by siege trains and specialized equipment [Ref. 8, pp. 4-18]. Although the looting, enslavement and killing of prisoners continued, the size of these forces indicates the existence of very organized supply systems.

An example of the people possibly involved in support activities can be seen in Xerxes' expedition to Greece in 480 B.C. According to Herodotus, the total number of persons that accompanied Xerxes on this campaign was more than five million. In those years, the followers of an army would include bodyguards, older soldiers exempt from combat duty, hostages, servants, seers, physicians, sophists, poets, historians, tutors, secretaries, surveyors, transport guards, soothsayers, courtesans, musicians, engineers and a siege train [Ref. 11, p. 11].

Considering that contemporary writers were known for exaggerating numbers, and even reducing Herodotus numbers

by two thirds, the total number of people involved in the campaign would still have been between 1.5 to 1.8 million (Davis in Ref. 6 is inclined to accept that even 2.5 million people is not an outrageous number). Other writers estimate Xerxes' fighting forces from 150,000 to 180,000 men. [Ref. 6, p. 14]. In this case, the TTR of Xerxes' army was close to 9 to 1 (9 followers/supporters for every fighter).

## D. THE LOGISTICS OF THE MACEDONIAN ARMY

The Macedonian Army between the years 350 to 320 B.C. was probably the best military force known to humanity up to that point and maybe even up to the 15$^{th}$ century when gunpowder weapons were introduced. For the first time in history, scientific analysis was used to design tactics and battle movements. Philip of Macedon developed the most thorough administrative and logistics system known and his son Alexander was the first to devise and use prototypes of field artillery that could be carried by mule or horse to the battle. [Ref. 8, pp. 50-53]

Alexander, like most of his contemporary generals, made extensive use of conquered districts' resources. However, evidence suggests that on occasion he had to import food and water from great distances to support his men and animals. In fact, the success of Alexander's sustained military expeditions reflected in large part his careful logistics planning. [Ref. 11, pp. 2, 3]

A study to reconstruct the Macedonian's logistics system was conducted by Evans [Ref. 11]. The study calculated the consumption rates of food and water of the

army based on the nutritional requirements of men, horses, mules and camels, and on the number of troops, followers, cavalry, and baggage animals. The study argues that the Macedonian army used one servant for every ten foot soldiers and one for every cavalryman to carry supplies or needed gear. The infantry-cavalry ratio was about six to one which translates to an overall ratio of one servant for every four combatants. During Alexander's reign it was estimated that for every two combatants there was one follower [Ref. 11, pp. 10-25]

Additionally, armed servants called 'psiloi' were usually used to guard the camp and baggage trains. The normal organization of the army called for approximately 1000 'psilois' per 7,000 combatants in a phalanx [Ref. 8, p. 51].

The numbers above would reflect a TTR of 1 to 1.12 (1 servant/follower for every 1.12 fighters). These numbers differ greatly from other contemporary armies. The main reason for this efficiency is that "both Philip and Alexander's troops carried their arms, armor, utensils, and some provisions while marching and did not use servants or carts to carry these items…" [Ref. 11, p. 12]

## E. THE ROMAN LEGIONS

The Roman military system was based on an essentially professional citizen army. The Roman armies were successful because they introduced a new organization based upon age and experience rather than wealth or social condition. Rome traditionally had two consular armies, each consisting of 18,000 to 20,000 men. Each consular

army was formed by two Roman and two allied legions, but in times of war there might have been more than the 8 standard legions. By 220 B.C. the total military manpower of Rome was calculated to be 750,000 men. [Ref. 8, pp. 79, 80]

If the numbers above are credible they indicate that from the 750,000 men in the militia system, 40,000 conformed the two consular armies and the rest had to be support personnel; a rough calculation will show a TTR of 18 to 1. If 220 B.C. included more than the 8 standard legions, the TTR would be slightly lower; however it would still be significant.

Because military service was mandatory for males between 17 and 60 and men over 47 only served in the garrisons [Ref. 8, p. 79], a simplification can be made to assume that roughly 30% of the men served in the garrisons and no more than 500,000 men were able to serve in the consular armies. If this simplification is accepted, then a new TTR of about 10 to 1 can be calculated for the field forces. This rate is similar to the one calculated for Xerxes' invasion army but a lot higher than the Macedonian army's TTR.

## F. MILITARY SYSTEMS IN THE FEUDAL ERA AND MIDDLE AGES

Charlemagne's military system of calling men to service through his noble vassals is considered one of the predecessors for the development of the feudalism of the middle ages. Feudalism was based on the military concept of local defense. The king would confer lands to the lords, and in return they would pay the king by allowing him to use men from their district on military operations

for a given period each year. This process allowed the kings to maintain standing armies throughout the year without excessive damage to the economy or without antagonizing friendly areas by the normal foraging and plundering of the armies of that period. [Ref. 8, pp. 225, 226, 264, 265]

Although no numbers are available to determine a TTR for the armies of this era, feudalism represents an intuitive cost-effective use of forces. This concept in turn led to another economical scheme: nobles would raise mercenary forces and then hire them out to kings who didn't have the funds to maintain full-time armies [Ref. 8, pp. 301-356]. In this way, if each soldier had to provide his weapons, and buy his supplies and elementary necessities, the logistics requirements for the king were practically nil.

In times of peace, these mercenary companies became a menace due to their illicit activities. The French solution to this problem in the 15$^{th}$ century was to create a standing army which was based on the 'lance.' Each lance consisted of a gendarme, a squire, 2 archers, and 2 pages or valets who served as foragers, scouts and pickets and were not counted as combatants [Ref. 8, pp. 434-444]. This basic organization results in a TTR of 1 support person for every two fighters. Of course, when these lances were grouped in companies or forces, the ratio must have increased.

## G. TAIL TO TOOTH RATIO IN THE UNITED STATES MILITARY

During the early period of the American Revolutionary War, the War of 1812 and the Mexican-American War of 1846, U.S. military logistics underwent many changes, from a completely decentralized concept to a centralized one that would be the first stone of today's logistic system. [Ref. 37, p. 5]

In 1775, during the American Revolution, independent agencies like the Commissary General, the Quartermaster General, Army Engineers and a military medical department were introduced by the Congress. At that time, the Congress also decided that the individual colonies should provide the necessary men and supplies for the army. Troops were required to provide their own weapons, ammunition, food and clothing. The army lived off of the total exploitation of the regions through which it marched. A private contracting system was established to meet the army needs; however the acquired supplies sometimes could not be delivered because the transportation system (also private) was not adequate or there were no funds to pay for the transportation. [Ref. 37, pp. 5-22]

Under these conditions, it can be assumed that the personnel TTR was very low for the army of the Revolutionary War.

Prior to the Civil War in 1861, the conditions under which the army operated were not much different from those present at the end of the Revolutionary War. The size of the standing army was close to 16,000 men and there was no logistics system to deal with the support requirements.

The states were still responsible for feeding, equipping and clothing the troops, with a subsequent reimbursement by the federal government. On the other hand, the overall economic infrastructure was different; food supplies were plentiful, roads and railroads allowed the supplies to be easily moved to camp, and the industrial base had expanded significantly. [Ref. 37, pp. 32, 33]

Combat operations frequently were subordinated to the supply and maintenance of the armies. The practice of foraging was officially discouraged; however it was used extensively when armies became self-contained and without external supplies. Often groups of businessmen would follow the armies selling a variety of goods directly to the soldier due to the inadequate size of the soldier ration. [Ref. 37, pp. 32-47]

Consequently, the personnel TTR for the armies during the Civil War was small; however, the kind of “outsourcing” which produced this reduction in TTR, by exploiting the soldiers and the civilian population, was not one that modern armies are advised to follow.

The characteristics of war changed radically during World War I and II. The global scope of these two conflicts made them completely different from any war mankind had seen before. In the case of the U.S., for the first time the whole nation was at war, and the economy was committed to the production of war goods. Troops and equipment had to be transported by land, sea and air across huge distances. Technology improvements and the appearance of more complex systems and weapons also created new logistical demands. Concepts like systems maintenance and

weapons repair, both “in place” and “depot level,” were introduced. Completely new organizations were needed to create, manage, administer and support the vast amount of forces the U.S. needed to get into combat. [Ref. 37, pp. 59-124]

All the above circumstances created an explosive increase in the number of organizations, agencies, staffs, and personnel in the U.S. Armed Forces between 1915 and 1945. This massive buildup of forces and the lack of a managerial system, like the PPBS, make it very difficult to calculate a TTR for the U.S. military during this period in history.

With the introduction of the PPBS and the MFPs in 1962, there is better information to determine a TTR. Figure 3-1 shows the changes of the DoD “tail” as a percentage of TOA since 1962 and projected through 2007 [Ref. 40, Table 6-5]. As was mentioned in chapter II, some MFPs are considered either “tail” or “tooth.” Figure 3-1 also illustrates the two different approaches, Case A considers MFPs 1 through 5 and 11 as combat forces programs or “tooth,” while Case B considers that only programs 1, 2 and 11 are really “tooth.” Regardless of the approach employed, Figure 3-1 shows a large increase in the “tail” during the Vietnam era, and also a constant growth of the “tail” starting around 1986 and up to 2002. The projection for FY 2003-2007 indicates a reduction of about 4% in the “tail.”

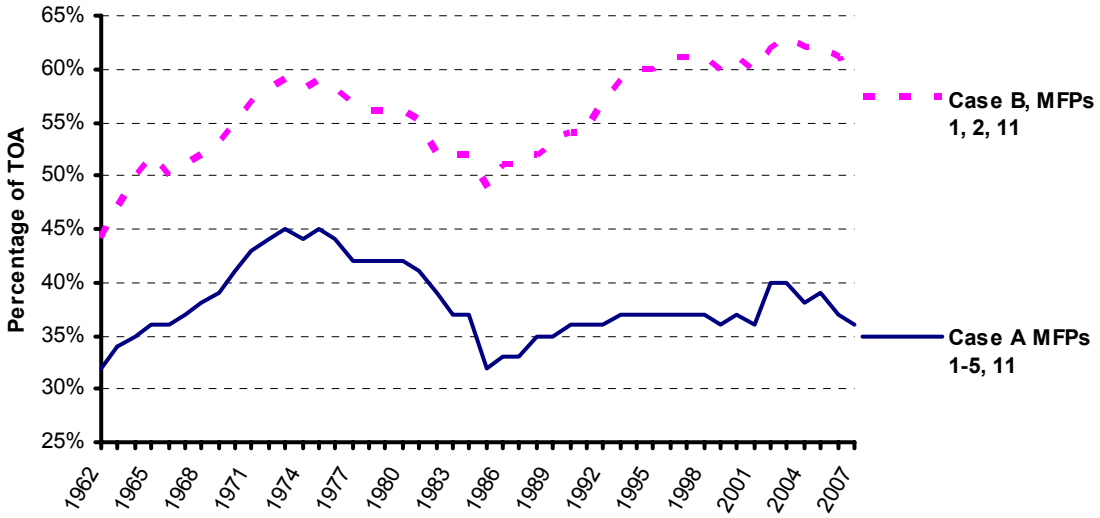


**Figure 3-1, Size of the DoD "tail" Since the Introduction of the PPBS**

In relation to the personnel TTR of the U.S. forces, Figure 2-12, Chapter II, shows that this ratio was around 55% to 59% over the past 5 years.

## H. SUMMARY

This chapter illustrates how support and logistics activities have been an integral part of all military operations throughout history. Military historians have recognized the significance of logistics for centuries and the great military commanders have been those who have best managed the logistics of their armies.

Using the "combat vs. support personnel" approach, a TTR was estimated for several periods of military history. These TTRs have varied from very low percentages in the ancient armies, to almost 95% in the Roman Legions, back down to approximately 55% in DoD in the past years, as shown in Figure 3-2.

However, the armies that have been able to reach those low TTR levels accomplished them by using methods that go

against modern rules of war, even to the point that they threatened the very population that they were defending and protecting.

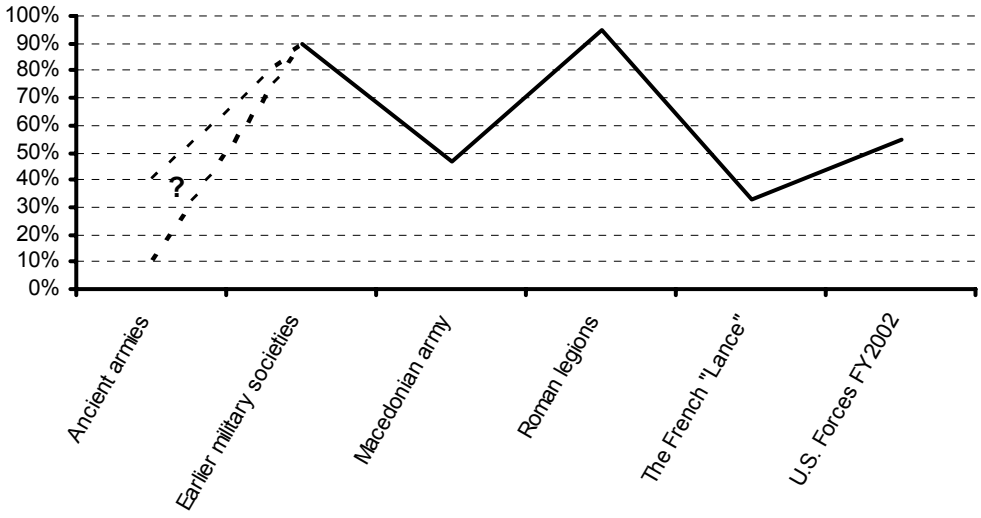


**Figure 3-2, Evolution of the TTR Based on the "Combat vs. Support Personnel" approach**

THIS PAGE INTENTIONALLY LEFT BLANK

# IV. ANALYSIS OF THE INFLUENCE OF TECHNOLOGICAL ADVANCES IN THE TTR

## A. INTRODUCTION

Chapter III illustrated how the need for logistics and support activities in military operations has changed throughout the centuries; and how the TTR has fluctuated due to these changes. History has shown that introducing and assimilating new military technologies and weapons can change the nature of warfare substantially.

This chapter will show that technology is a key factor that has contributed to the changes in TTR. The increasing dispersion of forces, reductions in the number of personnel on the front lines of combat, and new logistics organizations and agencies (“tail”) to provide for the ever increasing needs of the forces in combat are some of the features influenced by the changes in technology.

In recent years, the U.S. has increasingly relied on stealth, standoff, hypersonic, long-range, and unmanned systems. This chapter will focus on how these recent changes may affect the Operation and Support (O&S) costs and the subsequent breakout between “tail” and “tooth” on these future programs.

## B. REDUCTION IN THE TAIL AS A DIRECT EFFECT OF ADVANCES IN TECHNOLOGY

Often times introducing a new weapon or technology leads to a direct reduction in “tail” and a corresponding

increase in “tooth,” as was the case with the introduction of the sail in naval warfare.

In the 15th century, Mediterranean galleys traditionally had a total crew of 400, of which approximately 320 were oarsmen and the rest sailors and a small contingent of soldiers. Most galleys had 3 to 5 small cannons mounted in the bow [Ref. 8, p. 503]. In the early 16th century the first sail vessel designed specifically for war was the Galleon. The mid-sized Spanish version of the galleon carried approximately 14 officers, 23 seamen, 20 apprentices, 14 pages, 22 gunners, an infantry company of at least 100 troops and 20 to 40 guns of varying calibers. [Ref. 34]

During the transition from the age of the oar to the age of sail, the main objective in battle was boarding enemy ships. Based on this objective, only the infantry component and the sailors could be considered “tooth.” Consequently, during the age of the oar the “tooth” on the galleys was approximately 20% (80/400), and the introduction of the sail increased the “tooth” to close to 82% (159/193) on the galleons (the apprentices are not counted as “tooth”).

## C. INCREASE IN THE “TAIL” AND/OR REDUCTIONS IN THE “TOOTH” AS A DIRECT EFFECT OF ADVANCES IN TECHNOLOGY

In other historical examples, introducing a new weapon or technology either increased the “tail,” reduced the “tooth,” or in some cases both.

For example, the invention of rapid-firing guns and machine guns produced a dramatic increase in the need for

ammunition. The Germans based their prediction of ammunition needs for WW I on the Austrian war, where they fired an average of 200 rounds per gun. In 1914 at the start of the war they had 1000 rounds available per gun. A month and a half into WW I the Germans realized that all their rounds were expended. Due to the increased rate of fire, the weapons that normally lasted throughout the entire war now had to be repaired. This resulted in the need for and later creation of new logistics organizations and agencies (“tail”) to provide for the ever increasing needs of the forces in combat. [Ref. 37, p. 63]

In time, the increase in effectiveness and lethality provided by these rapid firing guns created a substitution effect, i.e. less rifles/soldiers (“tooth”) were needed/desired in the combat front. In fact, throughout history the strategies and tactics to employ new weapons with significant increases in lethality have normally reduced the number of people exposed to the threat of the new weapon [Ref. 9, p. 337]. In other words, with every large increase in weapon lethality there has been a corresponding increase in dispersion or a reduction in number of personnel on the front lines of combat (i.e., reduction in the “tooth”).

Dupuy [Ref. 9] studies the increase in the lethality of weapons throughout the ages. He describes the relationship between the years in history, the ‘theoretical killing capacity per hour' of the weapons and the dispersion in square meters per man in combat. Because the actual lethality of a weapon decreases as the dispersion of the troops in combat increases, the study combined these

two factors to develop an "Operational Lethality Index (OLI)." Appendix B, Table B - 1 summarizes these concepts. The OLI shows the relative battlefield values of weapons in different historical eras.

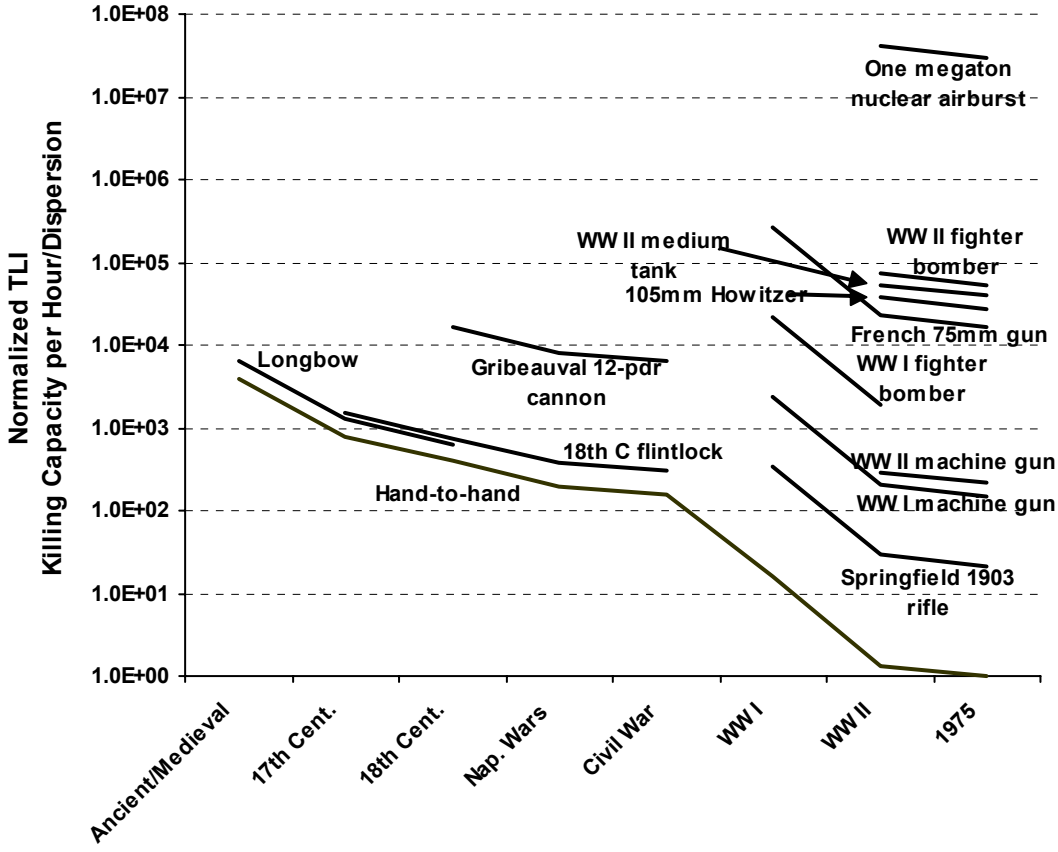


**Figure 4-1, Some Values of the Normalized Comparative Operational Lethality Indices**

In this thesis, the OLI is used to show how technology has reduced the number of soldiers on the combat front per unit of area needed to obtain a specific level of lethality or a required level of deterrence. In order to obtain a more descriptive measure, this research developed "Normalized Comparative Operational Lethality Indices." These indices are shown in Table B - 2 Appendix B and Figure 4-1. The values were normalized by assigning the value of 1 to the OLI of hand-to-hand combat in 1975; the

graph shows the reduction in lethality of the weapons with the increasing dispersion of the troops in combat.

For example, as Table B - 2 and Figure 4-1 show, with the normal dispersion factor of troops in 1975, replacing the lethality/deterrence of a one megaton nuclear airburst, would require about 30 million ancient/medieval soldiers fighting hand-to-hand, or about 140,000 soldiers with WW II machine guns, or about 600 WW II fighter bombers.

In other words, introducing a new technology such as nuclear weapons reduced conventional resources from the front lines of combat, which could be casually interpreted as a reorientation of resources between “force” programs. However, the reality is that whenever manpower is replaced by technology, some of the funds that were paying for soldiers (“tooth”) will now be paying for centralized command and control activities, centralized support and maintenance, acquisition infrastructure, research and development, and other activities generally considered as “tail.”

For example, the US Air Force today has 92% fewer airplanes and 91% fewer pilots than it did in World War II; in the 1950s, more than 40 percent of all Air Force officers were pilots; whereas today, pilots account for only 17% of the USAF officer force. Regarding these facts, Maj. Gen. Charles D. Link, USAF (Ret) commented that "Some may see this as an adverse 'tooth-to-tail' ratio. It is important to point out that the Air Force's large 'tail' produces a numerically small but militarily large 'tooth.' This is good. Fewer young Americans are at risk, while we

leverage aerospace superiority to achieve policy goals." [Ref. 4]

Reducing the “tooth” (force structure) should also bring a reduction in associated infrastructure activities, like central training, central personnel and central medical. However, these three categories represent approximately 30% of the total infrastructure categories, versus 60% in categories such as acquisition infrastructure, central logistics, installation support, and command, control and communications that normally grow with the introduction of new weapons and technologies [Ref. 50, p. 12]. Additionally, savings in infrastructure resulting from force structure reductions historically lag a few years behind the actual change [Ref. 51, p. 13].

This phenomenon is not exclusive of DoD’s technological advances. In the corporate world, companies frequently trade increases in fixed costs for lower variable costs whenever they invest in cost-saving technologies. Some of the investments in technology may be associated with production lines (“tooth”), but in many cases they are associated with office and service automation (“tail”). [Ref. 16, p. 64]

The bottom line in the corporate world then is not whether the investment in technology is being performed in the “tooth” or in the “tail” of the organization, but whether the investment will actually reduce the overall costs of production.

The comment by MG. Link presented above highlights an interesting point; there is a difference between the “numerical tooth” and the “military tooth.” In other

words, as is the case in the corporate world, it is not the size of the "tooth" and consequently the size of the "tail" that really matters; the important issue is how efficiently the one supports the other to boost the combat capabilities of the force.

## D. PRECISION-GUIDED ORDNANCE AND LONG-RANGE UNMANNED SYSTEMS

The trend towards smaller but more lethal forces, distributed throughout a theater of operations, while maximizing the use of more lethal weapons is part of the US vision for future warfare [Ref. 39]. The goal of these new tactics and technologies is to reduce collateral effects and the risks faced by the combat forces.

Some approaches being considered include: enhancing U.S. reliance on stealth, standoff, hypersonic, long-range, and unmanned systems; increasing the high-volume precision strike capabilities by fielding the Tactical Tomahawk missile and the Extended-Range Guided Munition; distributing forces throughout a theater of operations and developing new network-centric concepts of warfare; and developing ground forces that are lighter, more lethal, more versatile, more survivable, more sustainable, and rapidly deployable. [Ref. 39]

Specifically regarding the unmanned systems and precision attack weapons and technologies:

> The 2003 budget increases the number of unmanned aircraft being procured and accelerates the development of new unmanned combat aerial vehicles capable of striking targets in denied areas without putting pilots at risk. The budget includes $1 billion to increase the development

> and procurement of Global Hawk, Predator, and several new varieties of unmanned vehicles and to begin development of the Navy's Unmanned Underwater Vehicle….
>
> …DoD is taking steps to shift the balance of its weapons inventory to emphasize precision weapons— weapons that are precise in time, space, and in their effects. New classes of hypersonic weapons will provide precision in time— arriving at their designated aimpoints when they are needed. GPS-guided munitions such as the Joint Direct Attack Munition will provide precision in space — striking targets with unparalleled accuracy in any weather condition, day or night. And new classes of kinetic and non-kinetic weapons will provide precise effects — minimizing collateral effects while maximizing their intended effects whether they be holding underground facilities at risk, defeating chemical or biological weapons, or rendering enemy command and control systems unreliable. [Ref. 39, pp. 79, 81]

Some of these systems are already deployed, "…the victories in Afghanistan were won by 'composite' teams of U.S. Special Forces on the ground, working with Navy, Air Force and Marine pilots in the sky (using precision-guided bombs)…. Putting U.S. Special Forces on the ground early to assist with reconnaissance, communications and targeting dramatically increased the effectiveness of the air campaign…." [Ref. 39, p. 30]

Two important characteristics of unmanned and precision attack systems, accuracy and reliability, are also two of the basic factors considered to calculate the theoretical lethality index of a weapon system [Ref. 10, pp. 19-23]. Based on that fact, it is logical to infer that unmanned systems and precision attack weapons have or will have a high OLI, and that, as in the past, the

assimilation of these new technologies will result in a larger reduction/dispersion of troops in the combat front (i.e. an apparent reduction in “tooth”).

For example, DoD currently has 90 UAVs in the field, equivalent to 0.6 percent of the military aircraft fleet, i.e., there are 175 manned aircraft for every unmanned one in the inventory. By 2010, this inventory is programmed to grow to 290, with UAVs replacing manned airplanes in a wider variety of tasks because of their advantages in certain mission areas, commonly categorized as “dull, dirty, and dangerous” [Ref. 30, pp. i, ii].

From the TOC point of view, comparisons between manned and unmanned systems have shown that the only differences are in the operations and support costs. Historically development costs to reach first flight have been essentially the same. Although experience shows that the production cost of an aircraft is directly proportional to its empty weight, the savings from deleting the cockpit, displays, and survival gear from the manned airplane must be applied to the “ground cockpit” of the UAV aircrew, which typically offsets any difference in acquisition costs. [Ref. 30, pp. 51-54]

These are the main areas where UAVs may increase efficiencies and reduce O&S costs compared to manned aircraft [Ref. 30, pp. 54-55]:

- UAV crews do not operate in the same unique environment as manned aircraft crews do, the same limits to flight duration, and recovery time between flights do not apply to UAV crews. Due to that, the number of crews required to maintain a specific level of time airborne can be reduced. “At typical overseas detachments of intelligence, surveillance

and reconnaissance (ISR) aircraft (U-2s, RC-135s), three to five crews fly four to five 6-12 hour sorties per week. If the same number of UAV crews were used, using 6 to 8 hour shifts, they should be capable of conducting 7x24 operations for the same period or longer, a significant increase in crew availability." [Ref. 30, p. 42]

- In the future, the paradigm of one crew, one aircraft should give way to a concept of one crew, multiple aircraft, further multiplying the availability and reducing the total number of crews needed.
- If the aircrews are removed, the concept of aircrews practicing in their environment to maintain their flying proficiency and the need for continuation training sorties has to be revised. A large portion of the O&S cost for today's manned aircraft are due to training. In fact, 95% (50% for ISR aircraft) of the time flown by manned aircraft is in peacetime training of aircrews. UAV operators could receive the majority of their training in simulators, reducing the actual flight time for UAVs.

Although the possibility of lower sortie rates should also lead to reductions in certain support personnel, with their associated training and support costs ("tail"), it is clear from the list above that most of the cost reductions derived from the UAV programs, when compared to manned aircraft programs, will be in the number of operating crews and the need for field training ("tooth").

## E. CHAPTER SUMMARY

This chapter analyzed the influence that introducing and assimilating new military technologies and weapons has had on force structure. In some cases, the new technology produced a reduction in the tail. However, when a weapon with a large increase in lethality is introduced, there is a corresponding increase in dispersion or a reduction in some force program (i.e. reduction in the "tooth"); and an

increase in other activities generally considered as “tail.”

The “Comparative Operational Lethality Index” discussed in this chapter was used to show how the number of soldiers on the combat front per unit of area, needed to obtain a specific level of lethality or deterrence, has been reduced by the development of new technology.

The important issue regarding technological advances must be how efficiently the “tail” supports the “tooth” to boost the combat capabilities of the force and not whether the investment should be classified as “tail” or “tooth.” The corporate world uses a similar concept for its investments in technology. The focus is on the reduction of the overall costs of production; not on the area of the organization in which the investments are made.

Specifically, in the case of the US vision for future warfare; where unmanned vehicles are one of the approaches being considered, this chapter showed that although these programs will certainly produce a reduction in some activities considered “tail,” most of the cost reductions will be in categories normally regarded as “tooth.” Even with this expected decrease in the “tooth,” DoD’s overall capability to control and exploit the air will increase significantly.

THIS PAGE INTENTIONALLY LEFT BLANK

# V. ANALYSIS OF THE RELATIONSHIP BETWEEN TTR AND OPERATIONAL READINESS

## A. INTRODUCTION

This chapter will analyze how the design of maintenance and repair levels may impact the total life-cycle cost (LCC) of a program, and the breakdown of that LCC into its different areas.

Typically, the LCC of a system is separated into four areas: research and development (R&D), investment, operating and support (O&S), and disposal. As this chapter will show, when the percentage of the program's funds invested in each of these areas varies, the TTR of the individual program - and consequently that of the DoD (on a macro level) - varies accordingly.

Additionally, this chapter studies the relationship between the operational readiness of a weapon system - defined here as its operational availability - and the TTR of a specific program.

## B. IMPACT OF MAINTENANCE LEVEL DESIGN ON THE TTR

The percentage of the LCC attributable to R&D, investment, O&S, and disposal varies depending on the type of system. However, for major defense weapon systems the percentage breakdown of the LCC has been relatively constant throughout the years, as shown in Figure 5-1. [Ref. 31, Ch. II]

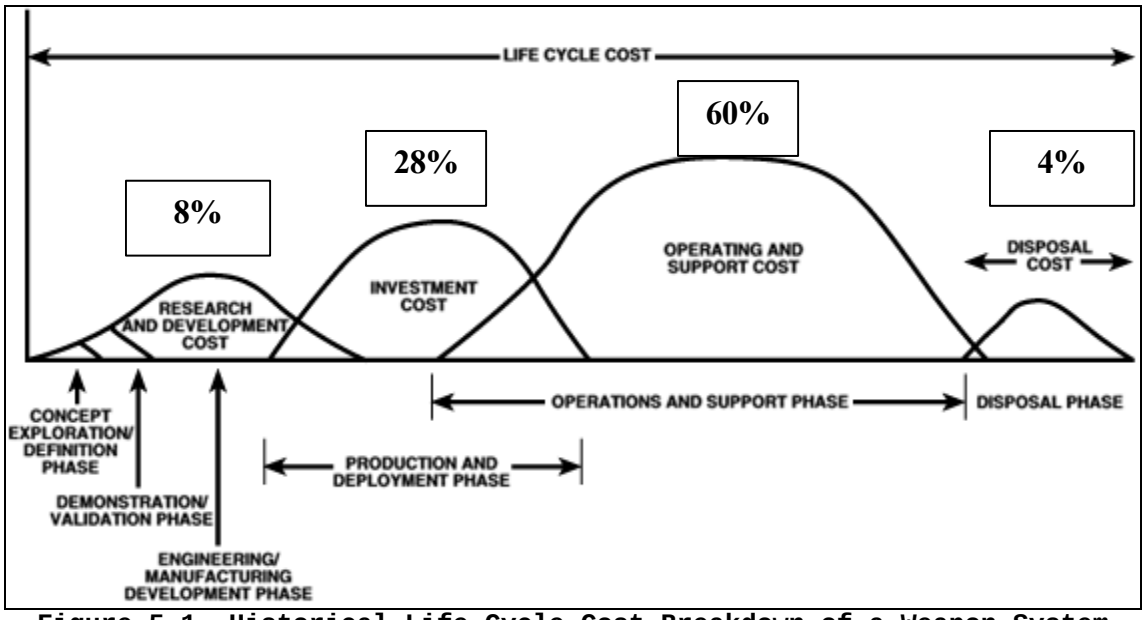


**Figure 5-1, Historical Life-Cycle Cost Breakdown of a Weapon System [From Ref. 31]**

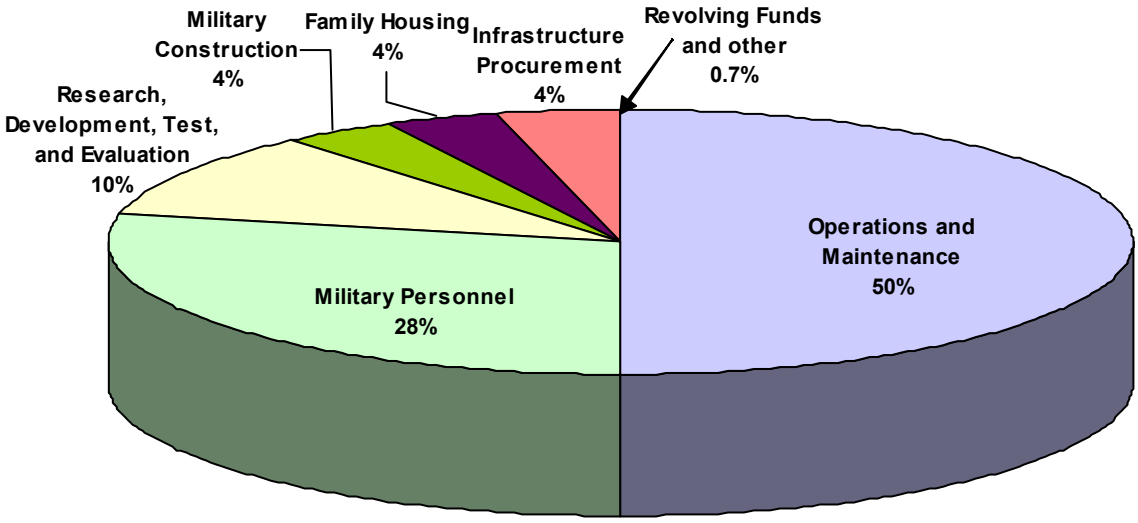


**Figure 5-2, Costs Normally Considered Infrastructure Grouped by Appropriation Category (Fiscal Years 1996-2001)**

This chapter is centered on the O&S costs of a system. This focus was chosen based on the information revealed in Figure 5-1, in which O&S costs have historically represented 60% of the total life-cycle costs of a weapon system. A secondary rationale for this focus is based on

the fact that the two appropriations that support the largest share of O&S costs - operations and maintenance (O&M) and military personnel – represent, according to some studies, 80% of the costs normally considered as infrastructure (see Figure 5-2 above). [Ref. 52, p. 10 and Table 2]

During the O&S phase of an acquisition program, three levels of maintenance and repair processes can be established [Ref. 7, pp. 12-14]:

- Organizational level maintenance: Lower level of maintenance, normally preventive actions performed by an operating unit on a day-to-day basis in support of its own operations.
- Intermediate level maintenance: Includes corrective maintenance of varied complexity, can be either part of the unit level organization or external to the unit and responsible for providing support to several units within an installation or geographical area.
- Depot level maintenance: Includes the costs of performing major overhauls or maintenance at centralized repair depots, contractor repair facilities or on site by depot maintenance teams.

According to the Goldwater-Nichols Act and the DoD definitions of mission/force categories and infrastructure categories presented in Chapter II, organizational and intermediate level maintenance must be considered “tooth” and depot level maintenance (Central Logistics) should be considered “tail.” Many studies and reports postulate, without in-depth analysis, that the reallocation of resources from the “tail” to the “tooth” always leads to an increase in efficiency. Following this line of thought, organizational and intermediate levels of maintenance can

be considered more cost-effective than depot level maintenance.

Such oversimplification is not always correct. For example, the Army selected the RAH-66 Comanche program to test innovative approaches to reduce O&S costs [Ref. 55]. In order to obtain these cost reductions, the Comanche was the first Army helicopter ever to be designed for a two level maintenance and repair process: organizational and depot level maintenance. Studies have shown [Ref. 7] that completely eliminating intermediate level maintenance, and improving reliability and maintainability of the helicopter, can indeed reduce O&S costs substantially.

According to the DoD's Selected Acquisition Report dated December 11, 2000 and the Congressional Budget Office, the total program costs of the RAH-66 Comanche helicopter are $48.1 FY2000 billions. Once adjusted for inflation (using the Gross Domestic Product (GDP) deflator inflation index), the total O&S costs for the program are approximately $15.26 FY2000 billions according to Dellert [Ref. 7], and $17.2 FY2000 billions according to the Program Management Office (PMO).

These two calculations indicate that the O&S costs will represent between 31.7% and 35.8% of the total RAH-66 Comanche program costs. These percentages are much lower than the historical 60% of the O&S phase for major defense weapons systems. Although it is not specified by Dellert [Ref. 7], it is safe to assume that most of the intermediate maintenance functions will move to Depot Level instead of Operational Level. Two facts support this assumption: first, by definition only low level maintenance

actions are performed at the operational level, increasing this capability implies a large investment in infrastructure, test equipment, etc; secondly, modern aircraft are highly modular, which implies that operational level maintenance is normally restricted to changing spares, while higher levels of maintenance manage the repair processes. Contrary to the concept of always eliminating the "tail," this example shows that an increase in the "tail" can reduce total LCC.

It is important to draw attention to the fact that the total O&S cost estimates for the Comanche program provided by Dellert [Ref. 7] and the PMO are initial estimates. Most aircraft, as they age, experience higher O&S costs and lower operational availability ($A_o$) than those originally projected during the procurement phase. Currently planned useable life for the Comanche is 20 years; however, almost all DoD platforms have been around longer than originally anticipated and it is unlikely that the Army will dispose of the system in the designated timeframe. Additionally, the Comanche was designed with ambitious reliability and maintainability goals; any deviations from those goals or any increase in the projected flying hours of the platform will raise O&S costs. [Ref. 7, Ch. IV]

## C. RELATIONSHIP BETWEEN OPERATIONAL READINESS AND THE TTR

The readiness or $A_o$ of a weapon system is defined as the probability that a system or equipment, when used under stated conditions in an actual operational environment, will operate satisfactorily when called upon (i.e. at a random time). This value provides the percentage of weapons

systems in mission capable status, or the percentage of time that a system is in mission capable status in the long run. [Ref. 18, p. 10]

The readiness or operational availability ($A_o$) can be expressed as:

$$Ao = \frac{uptime}{uptime + downtime} = \frac{MTBM}{MTBM + MDT}$$

MTBM is the mean time between maintenance; and MDT is the maintenance downtime, the total elapsed time required to repair and restore a system to full operating status (i.e. the turn-around time(TAT)). [Ref. 18, p. 9, 10]

Using the definition of Ao, the number of mission capable systems (MCS) is:

$$MCS = Ao \times Total\ Nr\ of\ Systems$$

In other words, given a required number of MCS for any weapon system, the total number of systems that must be acquired can be decreased by improving weapon system readiness (i.e. increasing MTBM and/or decreasing MDT). Increasing MTBM implies improving the reliability or quality of the systems, while decreasing MDT means reducing repair time and administrative/logistics delay times [Ref. 17, p. 28].

The above paragraph indicates two different approaches to obtaining a required MCS. The first is to produce a large inventory of weapon systems, i.e. to increase the "tooth;" Kang has called this approach the concept of "readiness at any cost" [Ref. 17, p. 27]. The other approach involves committing more resources to areas like R&D, increasing depot level maintenance capacities, or

improving logistics information/administrative systems, which are normally considered “tail.”

According to Kang [Ref. 19], the Standard Depot Level Maintenance (SDLM) for the U.S. Navy’s F/A-18 Hornet must be done every 4 years and the desired SDLM TAT is 6 months, which defines an expected Ao (disregarding downtime for Operational and Intermediate Level maintenance) of:

$$Expected \quad Ao = \frac{4}{4+0.5} = 0.889$$

If the Navy has a total of 774 F/A-18 aircraft, then the expected number of mission capable aircraft ($MCA_e$) is:

$$MCA_e = 774 \times 0.889 = 688$$

However, for a number of reasons the current SDLM TAT is 12 months, i.e. the current Ao is:

$$Current \quad Ao = \frac{4}{4+1} = 0.8$$

And at this level of Ao, the Navy will need 860 aircraft to maintain 688 MCA.

$$Needed \quad Aircraft = \frac{MCA_e}{Current\ Ao} = \frac{688}{0.8} = 860$$

Under the concept of “readiness at any cost,” to maintain the same level of readiness the inventory (“tooth”) must be increased by 86 aircraft. Alternatively the same effect can be obtained by investing in the depot level maintenance capabilities (“tail”) needed to reduce the SDLM time to 6 months. A complementary approach would be to reduce the administrative/logistics delay time.

As indicated above, there is a direct relationship between the spare parts inventory (aircraft in this case) and the readiness of the aviation fleet. An increase in the number of airplanes (an increase of budget in the

'tooth') should normally lead to an increase in readiness. However, such is not always the case. [Ref. 20]

Kang, et all. [Ref. 21] utilize a model to calculate Ao for an aircraft squadron that operates 20 single-engine aircraft and maintains its own repair facility. The model assumes that engine failures follow an exponential distribution at a rate of one per aircraft per 100 hours (i.e. failure rate/AC = 0.01), and the time to repair is exponentially distributed with a mean of 5 hours (i.e. service rate = 0.2). Every time an engine fails, it is removed from the aircraft and a spare engine is installed, if available. The faulty engine is sent for repair. If a spare is not available when an engine fails, the aircraft is grounded until a spare engine is repaired and delivered. The model was used to compare two different scenarios; the results are shown in Figure 5-3.

The first scenario demonstrates that an increase in the spare parts inventory may provide a higher Ao. However, the law of diminishing marginal utility or returns applies, and the marginal increase in Ao decreases as the number of spares is increased. In the example analyzed by Kang, et all. [Ref. 21], with 0 spares the average Ao = 0.841. With one spare, Ao = 0.863, an increase of 0.022; while going from nine to ten spares increases Ao only by 0.004.

For the Scenario 2, the average repair time increases from 5 hours to 10 hours (i.e. the repair rate is now only 0.1 AC/per hour) but the maximum failure rate (when all the aircraft are in operational mode) remains the same at 0.2 AC/per hour (0.01 x 20 aircraft). This means that in the

long run, 50% of the aircraft will be inoperable, regardless of the number of spares (“tooth”) in the system. Figure 5-3 confirms that in scenario 2 Ao will remain constant even with additional spare parts available. Kang [Ref. 20] expands on these concepts.

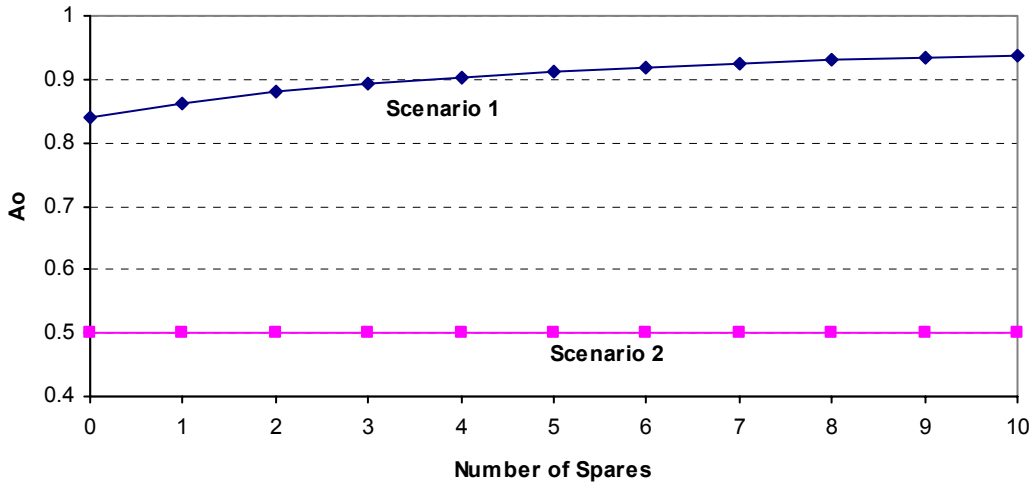


**Figure 5-3, Operational Availability for Different Repair Times and Sparing Levels [From Ref. 21]**

As this example shows, increases in the ‘tooth’ do not always lead to increases in operational readiness. There should always be a balance or trade-off between investing in equipment (sparing levels or “tooth”) and investing in logistics or administrative capabilities (“tail”).

DoD’s expansive weapons inventory is aimed at maintaining the highest possible level of military readiness. This, however, is in direct contrast to the corporate world where high levels of inventory are seen as an unnecessary and expensive liability. Although in both the defense and commercial sectors, high inventory levels may improve “readiness” by making sure goods are always

available. This is a costly approach which is subject to obsolescence and pilferage. [Ref. 17, p. 7]

## D. CHAPTER SUMMARY

This chapter studied how the design of the maintenance and repair processes of an acquisition program can influence the total LCC of the system. The examples given demonstrated that the organizational and intermediate level maintenance are not always more cost-effective than depot level maintenance. Contrary to the widely accepted belief that the key to efficiency lies in eliminating the "tail," increases in the "tail" often lead to reductions in total LCC.

Many of the studies that call for reducing the TTR, state that DoD must reduce the operating, support, and infrastructure costs. The ultimate objective is that any savings realized through this process be applied to the "tooth," to sustain adequate levels of readiness. However, increasing the inventory ("tooth") is only one possible way to improve readiness, sometimes increasing the depot level maintenance and/or the administrative/logistics capabilities ("tail") may be better alternatives.

The economic theory, supported by empirical evidence, of diminishing marginal utility or returns is as applicable in this case as in any other economic aspect. As the amount of "tooth" is increased, holding all other inputs constant, the amount that readiness increases for each additional unit of "tooth" will generally decrease. Thus, in every case a cost-effectiveness analysis should be used to

determine the best method to reduce costs while also improving readiness.

THIS PAGE INTENTIONALLY LEFT BLANK

# VI. TAIL TO TOOTH RATIO WITHIN THE CORPORATE WORLD

## A. INTRODUCTION

For the past two decades, DoD has started several initiatives to search for "best business" practices in the corporate world and implement them into its operations. These practices are aimed at streamlining management oversight, eliminating redundant functions, and outsourcing or privatizing activities to the greatest extent possible. Jack Welch took a similar approach with General Electric (GE) when he directed the company to sell or close any business unit in which they were not number 1 or number 2 in that market niche [Ref. 3]; this directive forced GE to take a serious look at which businesses were really adding value to the company.

The corporate world’s financial aim is to create shareholder value. In DoD, a purely non-profit organization with many and varied missions, there is no way to determine the bottom line from an accounting perspective. The efficiency objective in DoD, however, is similar to that in the corporate world: change its processes so that it can become a leaner, more flexible and more efficient organization.

One metric DoD evaluates to determine the success of such initiatives is the TTR. In Chapter II, several examples were given of how DoD defines and calculates TTR. This chapter offers an alternate point of view by exploring how this measure is defined, calculated and employed within the corporate world.

## B. TAIL TO TOOTH DEFINITION IN THE CORPORATE WORLD

Within the corporate world, as is the case within DoD, there are several ways to define what is “tooth” and what is “tail.” Three of these interpretations will be discussed within this chapter: the overhead versus the direct cost approach; the selling, general and administrative (SG&A) cost versus cost of goods sold; and finally the primary versus support activity approach. All of these approaches are focused on the corporate world’s bottom line: creating shareholder value and return on capital. [Ref. 44]

### 1. Overhead Versus Direct Cost

Two basic costs in financial terms are overhead and direct cost. Overhead costs are defined as “any costs not directly associated with the production or sale of identifiable goods and services; sometimes called ‘burden’ or ‘indirect costs’.” [Ref. 42, Glossary] Overhead defined in this manner can be considered similar to the military’s definition of “tail.” Direct costs are defined as “cost of direct materials and direct labor incurred in producing a product.” [Ref. 42, Glossary] Direct materials are “those materials that become an integral part of a company’s finished product and that can be conveniently traced to it,” whereas direct labor is “reserved for those labor costs that can be directly traced to the creation of products in a ‘hands on’ sense and that can be so traced without undue cost or inconvenience.” [Ref. 12, p. 26] In this context, direct cost is the “tooth” of the corporate world.

There has been a lot of controversy amongst accountants regarding direct costing.

> The controversy is over the theoretical justification for excluding fixed overhead costs from the cost of units produced and therefore from inventory. Advocates of direct costing argue… that the costs for facilities, equipment, insurance, supervisory salaries, and the like, represent costs of being ready to produce and therefore will be incurred regardless of whether any actual production takes place during the year. Advocates of absorption costing argue …that fixed costs such as depreciation and insurance are just as essential to the production process as are the variable costs, and therefore cannot be ignored in costing units of products [Ref. 12, p. 267]

It is clear from the above paragraph that the corporate world, like DoD, also has problems specifying what items are truly “tail” and “tooth.”

One method of accounting that can be used with this approach is Absorption Costing (Full-costing). Absorption costing is a product-costing method that assigns all manufacturing costs to a product: direct materials, direct labor, and overhead [Ref. 15, Glossary]. This method allows all manufacturing costs to be fully assigned to the product.

### 2. Selling, General and Administrative Cost (SG&A) Versus Cost of Goods Sold

Paul Strassmann, former Director of Defense Information, has been watching the corporate tail-to-tooth ratio for 20 years and defines it as the ratio of SG&A cost to the cost of goods sold. [Ref. 43]

SG&A is defined as expenses that are not specifically identifiable with, or assigned to, production. [Ref. 42,

Glossary] Selling costs are the costs necessary to market, distribute, and service a product or service. Examples of selling costs include: salaries and commissions of sales personnel, advertising, warehousing, shipping and customer service. Administrative costs are the costs associated with research, development, and general administration of the organization that cannot reasonably be assigned to marketing or production [Ref. 15, Ch. IV]

Cost of goods sold is the inventoriable costs that firms expense because they have sold the units. [Ref. 42, Glossary] The cost of goods sold can also be defined as the cost of direct materials, direct labor, and overhead attached to the units sold [Ref. 15, Glossary].

Strassmann believes that this approach is a good measure of how much overhead (transaction cost) is needed to support the delivery of a dollar's worth of goods and services [Ref. 43]. This definition would be analogous to a common definition of TTR within DoD – how many support personnel are needed to support the functions of one combat personnel. An appropriate accounting method that can be used to categorize this approach is Activity Based Costing (ABC).

***a) Activity Based Costing (ABC)***

The ABC method uses direct and driver tracing to assign costs to activities and then traces costs from activities to products. [Ref. 15, Glossary] This method is very different than the one taken by traditional cost accounting methods.

Traditional cost accounting methods suffer from several defects that can result in distorted costs for decision-making purposes. All

> manufacturing costs - even those that are not caused by any specific product - are allocated to products. And non-manufacturing costs that are caused by products are not assigned to products. Traditional methods also allocate the costs of idle capacity to products. In effect, products are charged for resources that they don't use. And finally, traditional methods tend to place too much reliance on unit-level allocation base such as direct labor and machine-hours. This results in overcosting high-volume products and undercosting low-volume products and can lead to mistakes when making decisions. [Ref. 13]

The ABC method assumes that cost objects generate activities that in turn consume costly resources. Activities form the link between costs and cost objects. Activity - based costing is also concerned with overhead - both manufacturing overhead and SG&A overhead. The accounting for direct labor and direct material is usually unaffected.

ABC should be viewed as a management process which examines how an entity’s activities consume resources and relate to its outputs. ABC can be used to break down an organization’s processes into activities, and measure each activity’s cost and performance effectiveness. This is accomplished by assigning costs to the related activities based on use of resources, and then by assigning costs to cost objects, such as products or customers, based on use of activities. Those costs that cannot be directly traced to activities or outputs are assigned to outputs based on a cause and effect relationship or through cost assignment.

Many private sector and several federal sector entities that have implemented ABC have chosen to designate activities as either value added or non-value added

activities. Value added activities are those activities that cannot be excluded without negatively affecting output quality; non-value added activities can be excluded without affecting output quality. Resource costs are assigned to activities. Next, activity costs are assigned to outputs. The costs that cannot be specifically traced to activities or outputs are then allocated to outputs.

This method helps corporations institute performance measures and gauge actual performance against these measures; it also requires a cross-functional look at resource consumption. [Ref. 45]

### 3. Primary Versus Supporting Activities

Another approach to defining TTR in the corporate world is the primary versus support activity approach. This approach is derived from the value chain concept. The premise of this approach is that all activities add value to the organization, but in order “to understand the firm's source of comparative advantage it is necessary to analyze internal activities that contribute to value creation.” [Ref. 47]

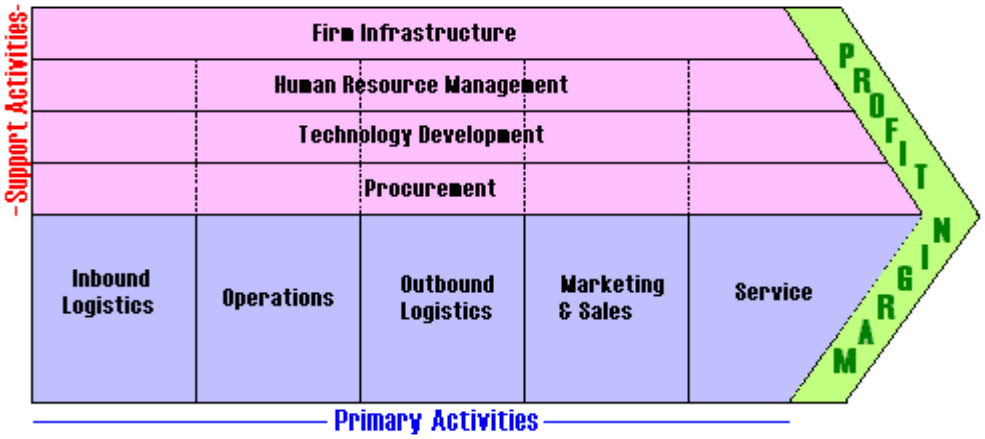


**Figure 6-1, Porter Value Chain Model Primary vs. Support Activities [From Ref. 47]**

Primary activities are those that create, deliver and service the product; while support activities are those that allow the primary activities to be performed (similar to indirect cost centers). [Ref. 47] The chart above illustrates how primary and support activities are related according to Porter’s value chain model.

Primary activities are:

Inbound logistics – acquiring inputs that are used in the product, such as warehousing, materials handling, and inventory control.

Operations – transforming inputs into the final product through such activities as machining, assembly, molding, testing, and printing.

Outbound logistics – activities related to storing and physically distributing the final product to customers, such as finished goods warehousing, order processing, and transportation.

Marketing and Sales – processes through which customers can purchase the product and through which they are induced to do so, such as advertising, distribution of catalogs, direct sales, promotions, and pricing.

Service – services to enhance or maintain product value, such as repairing, supplying parts, or installation.

Support activities which are placed above the primary activities in Figure 6-1 are:

Procurement – refers to the processes and activities involved in purchasing inputs and not to the inputs themselves, or to the way the inputs are handled once they are delivered.

Technology development – refers to the product and process development processes and to the organizational learning processes, which result in improved products and services and in improvements in the way organizational functions are performed.

Human resource management – includes human-based activities such as recruiting, hiring, training, performance evaluation, employee development, and compensation.

Firm infrastructure (Administration) – consists of general management activities such as planning and accounting. [Ref. 16, pp. 46-49]

Once all activities are categorized, they are examined as to costs and contributions to the firm's strategy. One way to examine these costs is through value chain analysis.

***a) Value Chain Analysis***

During the past 15 years, most U.S. corporations transitioned from large conglomerates to highly focused and specialized market-specific operations. During this period, these corporations identified their core competencies and reorganized to best capture the market niche that they hoped to fill. Often, if other competitors were better in an area than they were, they either restructured or got out of that market niche. The message during those years was: “Do what you do best and outsource the rest.” [Ref. 2]

Industry analysis is key to understanding how a firm fits and maneuvers within its environment. This analysis should indicate what costs, products, prices, and market choice strategies are key to gaining a competitive

advantage. However, to understand the firm's source of comparative advantage; it is necessary to analyze internal activities that contribute to value creation. [Ref. 47]

A value chain analysis is useful to assess how a firm creates an advantage. The value chain is the linkage across the activities of the firm. Each activity is viewed as creating, enhancing, or complementing value (profit) creation. The value chain provides the firm with a comprehensive framework to systematically search for ways to provide superior value to the customers. Every firm is a collection of activities that are performed to design, produce, market, deliver, and support its products. The division of the value chain into primary and support activities can help a firm understand existing and potential advantages and also low value or redundant activities or processes.

Throughout the corporate world, each firm has different activities and/or emphasizes different activities, which in turn provides unique ways in which profits are earned. [Ref. 47] In the retail industry, for example, Wal-Mart emphasizes the primary activities of logistics and operations to achieve low costs through economies of scale; Nordstrom emphasizes marketing, sales, and service to differentiate its higher quality, but higher price strategy. [Ref. 47]

If DoD could be thought of as a corporation with many different business units, it too would face the same issue as the corporate world; each business unit would have a different emphasis towards achieving the corporation’s strategic goals (which in DoD is intangible).

## C. SUMMARY

Table 6-1 summarizes the different interpretations of "tooth" and "tail" in the corporate world. The aspects that are common between the three definitions are presented in bold characters. Figure 6-2 presents the same information graphically.

**Table 6-1, Commonalities in the Definitions of "Tail" and "Tooth" in the Corporate World**

| Approaches to define "tooth" and "tail." | Overhead vs. Direct Cost | SG&A vs. COGS | Primary vs. Supporting Activities |
|---|---|---|---|
| **Tail** | - Overhead<br>- **R&D and G&A not assigned to marketing or production** | - Sales personnel, Advertising, Warehousing, Shipping, Customer service<br>- **R&D and G&A not assigned to marketing or production** | - Procurement<br>- **Technology development**<br>- **Human resource management**<br>- **Firm infrastructure (Administration)** |
| **Tooth** | - **Direct Labor**<br>- **Direct Materials**<br>- **Marketing**<br>- Sales personnel, Advertising, Warehousing, Shipping, Customer service assigned to a product | - **Direct Labor**<br>- **Direct Materials**<br>- **Marketing**<br>- Overhead | - Inbound logistics<br>- **Operations**<br>- Outbound logistics<br>- **Marketing** and Sales<br>- **Service** |

As the corporate world continually tries to reinvent itself, it has gone through several process reengineering efforts; to include – absorption costing, activity based costing, and value chain analysis. Because of the focus on the bottom line (profits) within the corporate world, it is easier to decipher what is "tooth" and what is "tail" in the corporate world than in DoD. However, even with this steady focus on profitability, disagreements still arise amongst business leaders regarding how this "tooth" and "tail" should be measured.

DoD, which is composed of many different functionally oriented business units, has no tangible or easily quantifiable bottom line on which to focus. Due to the

intangible nature of the organizational objectives, it has become increasingly more difficult to define the boundaries between “tooth” and “tail.” With the continued emphasis placed on “best business” practices, it is important to note that not all “best practices” are directly transferable from the corporate world to DoD.

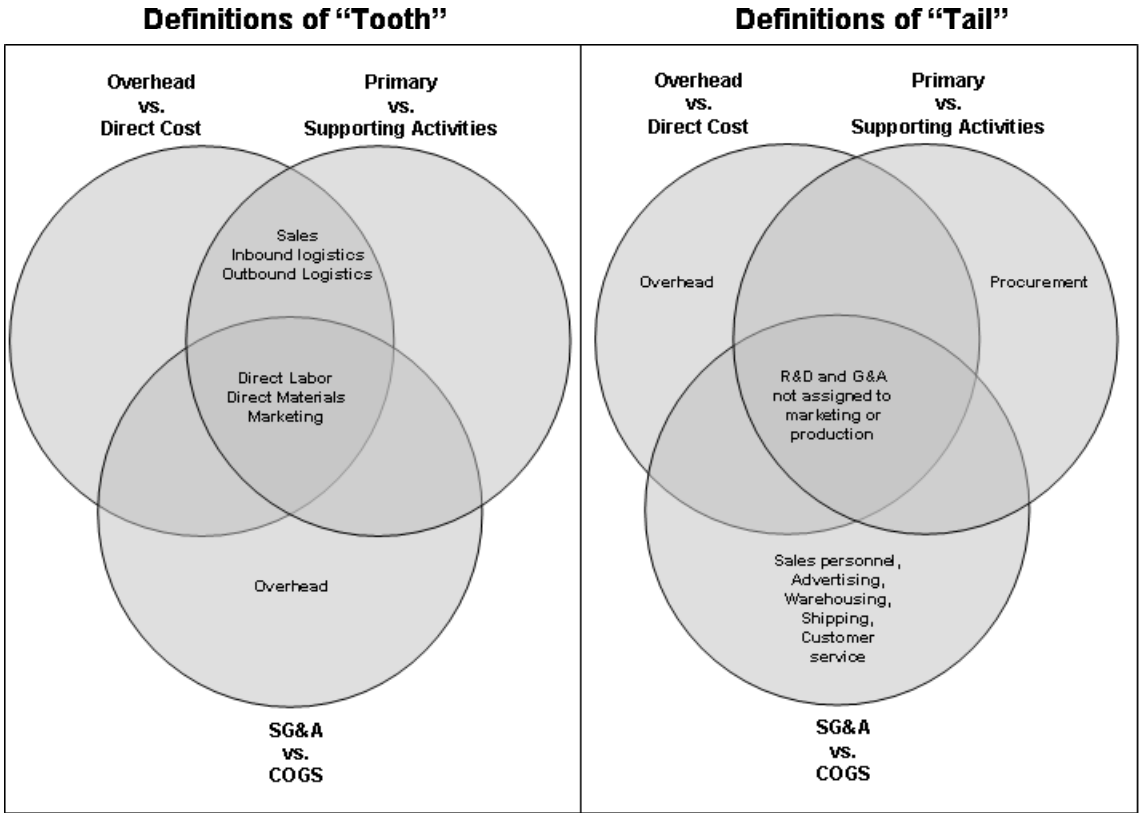


**Figure 6-2, Commonalities in the Definitions of “Tail” and “Tooth” in the Corporate World**

THIS PAGE INTENTIONALLY LEFT BLANK

# VII. A NEW APPROACH TO THE "TAIL-TO-TOOTH" RATIO

## A. INTRODUCTION

This chapter analyzes the boundary between "tail" and "tooth" through specific DoD cases and examples. These cases introduce variations on the specific situation, the environment and the timing of the measurement of the TTR; with the intention of investigating if such changes have any effect on the definitions of "tail" and "tooth," and consequently on the resultant value of the TTR.

A new approach for determining the TTR is investigated and used in a qualitative example to determine what may be considered "tail" or "tooth" in the US Special Operations Forces Command.

This section of the research culminates with the redefinition of the concept of TTR and the postulation of a new approach to define "tooth" and "tail."

## B. CURRENT DOD TTR DEFINITIONS UNDER FLUCTUATING CIRCUMSTANCES

Chapter II introduced the different approaches used in DoD to define "tooth" and "tail," and presented the advantages and disadvantages associated with each method. The "actual" TTR of DoD was calculated using the different approaches and each approach produced substantially different results. The main reason for these differences is that all of the methods attempt to establish an unambiguous boundary between "tail" and "tooth." This section will demonstrate that a clear limit does not exist.

On the contrary, the definitions of “tail” and “tooth” change with the specific situation, the environment and the timing of the measurement.

### 1. The Situationally Dependent Boundary Between “Tail” and “Tooth”

In Chapter VI, the cost component “Direct Labor” for the corporate world was defined as those costs that can be directly traced to the labor that creates the final product, i.e. labor costs that can be directly traced to the “tooth.”

In DoD the costs of labor are defined by the pay appropriations that make up each fiscal year’s budget. The following categories comprise the pay appropriations for Active Military personnel [Ref. 33, Table 6-3B]:

- Basic Pay
- Retired pay accrual
- Basic Allowance for Housing (BAH)
- Subsistence allowance
- Incentive pays
- Special pays
- Other allowances
- Separation pays
- Federal Income Contribution Act
- Permanent change of Station travel
- Cadets
- Miscellaneous

In the corporate world “direct labor” is an integral part of the costs of goods sold (COGS); in other words it is an essential component of the core business of a company. Following that concept, when any of the above cost categories is appropriated to pay for active military personnel laboring in an activity considered as “tooth,” then that cost must be considered as part of the core

business of DoD, i.e. the cost category becomes “tooth.” On the contrary, if the appropriations are paying for active military personnel working in activities considered “tail,” then those same categories becomes “tail.”

This is not the case in DoD’s current definitions of “tooth” and “tail.” For example, the infrastructure category ‘Central Personnel Benefits Programs’ includes all family housing programs, regardless of the job the Armed Forces member receiving the benefit performs. However, housing costs are an integral part of the labor costs of active military personnel; therefore, housing costs of military personnel working in the “tooth” should be considered direct labor costs or “tooth” and indirect costs or “tail” for personnel working in the “tail.”

To make this example more transparent, assume that all military family housing programs are privatized (of course this is not a viable alternative in many locations); and that instead of having a DoD organization in charge of providing housing benefits, every DoD military member is paid a housing allowance to rent from the market. In this case housing costs will indisputably be a direct component of labor costs, i.e. for every active member there is an associated housing allowance cost, and that cost exists if and only if that member remains on active duty.

The same notion should apply in the case of a DoD managed (or outsourced) housing programs. The only reason for such programs is to provide a service that is an essential part of the labor costs of active military personnel. For those members that opt not to live in military housing and currently receive a monthly housing

allowance as part of their salary, it is possible to allocate the costs of housing between tail and tooth. To be consistent, the costs of military family housing programs should also be allocated between “tooth” and “tail” according to the type of job and physical location of the Armed Forces member that receives the benefit.

An advantage of this approach is that it creates more visibility of the housing benefits costs, and it will clarify what portion of those benefits is directed towards personnel in the ”tooth” versus personnel in the “tail.”

As part of its efforts to reduce infrastructure, DoD is conducting several programs to find competitive sourcing of services in the marketplace; military family housing is one of those programs. Another advantage of allocating current housing program costs between “tooth” and “tail” is that when the transfer of military family housing to the private sector, as the preferred provider, is completed, it will be possible to determine the real budget appropriation that will be moved from the “tail” to the “tooth.”

This approach can also be used for all costs that can be traced directly to labor costs, i.e. when direct and indirect labor are the clear cost drivers. Applying this method should provide a TTR that portrays more closely those costs that cannot be reduced without damaging the effectiveness of the front line units. Although some of these costs may be called “tail,” all costs directly tied to the personal wellbeing of a combatant have a direct relationship on the combatant’s level of effectiveness.

Unfortunately, the problem of deciding which personnel resides in the “tooth” or the “tail” still remains unresolved.

### 2. The Environmentally Dependent Boundary Between “Tail” and “Tooth”

DoD is composed of a large number of administrative commands, defense agencies, offices and activities, that provide goods and services to a large variety of ‘customers.’ Those customers include combatant commands, other agencies in DoD, government agencies external to DoD, other countries and even civilian society. Who is the customer (i.e., what is the real output or service being provided) and not where that service is coming from, should be the criteria to decide if a service is “tooth” or “tail.” This concept is illustrated with the spatial Navigation and Force Tracking systems, which is heavily reliant on the Global Positioning System (GPS).

In 2001 the Commission to Assess United States National Security Space Management and Organization affirmed:

> The security and economic well being of the United States and its allies and friends depend on the nation’s ability to operate successfully in space… Specifically, the U.S. must have the capability to use space as an integral part of its ability to manage crises, deter conflicts and, if deterrence fails, to prevail in conflict. [Ref. 39, p. 93]

Additionally, DoD considers that all efforts to improve capabilities in Space, Information and Intelligence (SII) contribute directly to meeting all six of the DoD’s operational goals established at the QDR and enhance the

flexibility of the Armed Forces and their capacity to meet a wider range of contingencies. [Ref. 39, p. 93]

The following are the key areas of the military space capabilities [Ref. 39, p. 94]:

- Space launch, range operations, and terrestrial control networks;
- Intelligence, surveillance, reconnaissance (ISR);
- Satellite communications (SATCOM);
- Launch detection and tracking;
- Navigation and force tracking;
- Meteorology and other environmental support to military operations; and
- Space surveillance and control.

Navigation and Force Tracking systems provide worldwide precision position, navigation, and timing to both military and civilian users through the GPS satellite constellation. Future generations of GPS satellites will add a second civil frequency for all users. [Ref. 39, p. 96] This definition of navigation and force tracking systems reveals that the GPS is designed for and used in two different kinds of environments, i.e. two different categories of customers: civilian and military.

There are multiple military applications of the GPS, ranging from purely administrative, to logistics, operational navigation, and lately guidance of weapons. Current generations of standoff weapons employ GPS to guide themselves to geo-spatial coordinates loaded into the weapon prior to launch. In this manner, the GPS is acting similar to a Fire Control System for a fire and forget weapon. Each day GPS is becoming more and more essential for navigating and positioning air, surface, subsurface and ground units. GPS has also been used to improve logistics

systems; forces are currently increasing their use of GPS in real-time inventory placement and tracking.

It would be hard to argue that providing GPS information for civilian activities is part of the core business of DoD. But, as mentioned above, there are many military applications that are clearly part of the core business of DoD, and therefore must be considered “tooth.” However, until 2002 the GPS was explicitly included in the Command, Control and Communication infrastructure (“tail”) category. DoD’s new infrastructure categories (see Table 2-2), do not explicitly include the GPS within the Communications and Information Infrastructure category; however, it is also not included in any of the Force Structure categories (Table 2-1). Additionally, Chapter II - Section b) showed that some sources consider MFP 3, Command, Control, Communications, Intelligence and Space as infrastructure or “tail.”

One problem that arises when trying to classify GPS costs is that, contrary to housing or medical services, there is not a clear activity driver for these costs. Although there may be some functions that are specific to civilian or military use, in general the system works as a whole, which makes it very difficult to allocate GPS costs between DoD and non-DoD users. Even if an allocation were to be made for DoD, a further allocation is needed to separate services that are clearly combat related or “tooth” and services that are administrative support or “tail.”

DoD’s missions and objectives are growing both in number and in variety, especially in the field of

operations other than war (OOTW) and constabulary operations. Consequently, the fraction of DoD's SII capabilities that contributes directly to the Department's core competencies is also increasing. These facts suggest that a large percentage of SII costs, including GPS, should be considered "tooth."

However, some sources disagree with this concept and give more importance to the location from which the service is being provided:

> In our analysis of DOD's infrastructure and mission programs, we found that many intelligence, space, and command, control, and communications programs are excluded from the infrastructure, even though they appear to fit DOD's infrastructure definition. …These programs include installations, facilities, and activities that would not deploy with combat forces but would support those forces. …Although combat forces may link into these systems, the actual systems operate from fixed locations. We believe that by categorizing most intelligence, space, and command, control, and communications programs as mission activities, even though they appear to include infrastructure activities, DOD's accounting of infrastructure may not be complete. [Ref. 52, pp. 4, 5]

### 3. Time-Based Boundary Between "Tail" and "Tooth"

The categorization of activities as "tail" and "tooth" can also vary with time, especially between peacetime and wartime. Functions that can be clearly considered as non-core or "tail" at a time when there is no/little conflict developing, may be considered core or "tooth" activities during wartime or when the characteristics of the conflict change.

Over the last 15 to 20 years, private organizations have increasingly outsourced their non-core activities to generate efficiencies and savings. In recent years, DoD has gradually turned to the private sector to provide competitive sourcing of support services and functions that are considered commercial in nature. These activities may have been previously provided by government employees, or were simply new services that required skills not immediately available in the Department's military or civilian work force [Ref. 1, p. 14, 15].

DoD is establishing two types of agreements with the corporate world, outsourcing and privatization. Privatization means reducing government ownership and suspending any type of DoD competition with private industry. Outsourcing represents an intermediate step toward privatizing portions of DoD's infrastructure, it combines government ownership with private contracting for various functions. [Ref. 49, p. 24]

The basic notion is that DoD and the Services must separate from non-core activities, and should outsource or privatize support functions clearly appropriate to the private sector, i.e. if its "tail" it should be outsourced or privatized. The question then is what functions or non-core activities are appropriate for the private sector? According to LG Thomas G. McInerney, USAF (Ret.), Former President and CEO, BENS:

> BENS believes that, like American business in the 1980s and the US defense industry in the 1990s, DoD should focus on "core competencies" and outsource activities not critical to its mission. For the Pentagon, the core mission is to deter threats to US national security, and, if

> deterrence fails, apply military force to win on the battlefield. Activities that are not combat capable should be classified as non-core and should be considered for outsourcing or privatization - if such services can be provided more efficiently and effectively by the private sector. [Ref. 26]

Some sources consider that the privatization or outsourcing efforts should have an even larger scope:

> Any person or function that is not fully used in a necessary, core role in the Department is a “misallocation” that slows down the Pentagon and retards transformation. Every General, who pretends to be a “businessman” within some Defense Agency that the Department could privatize, detracts from combat capabilities. [Ref. 49. 18, 19]

These types of statements raise additional questions such as: Do only combat capable activities work to deter threats to US national security? What types of threats are being considered? Is the spectrum of threats fixed? What will be the battlefields of the future?

Currently, DoD needs to plan for the possibility of a major conflict, but must also: provide security for homeland defense; respond to small-scale conflicts and international terrorism; carry out peacekeeping, humanitarian relief and constabulary operations; combat illegal drug trafficking; and protect and secure access to US interests (overseas and in space).

With this broad range of missions, which include large scale and low intensity conflicts, OOTW, and operations without a clear enemy, it is very difficult to define an unambiguous limit between core and non-core, or combat capable and non-combat capable activities. This boundary

changes depending on whether or not there is an on-going conflict, the type of mission to be accomplished, the composition/definition of the enemy and the scope and intensity of the conflict. This increased operational tempo and missions has blurred the line between military and civilians performing combat activities. Lately, civilians from private companies have replaced active soldiers in everything from logistical support to battlefield training and military advice at home and abroad. [Ref. 57]

During this time of continued peace and low intensity conflicts, DoD has successfully used the private sector to provide services and products in various areas. Contractors have provided maintenance and base services support since the late 1960s, the Defense Logistics Agency employs direct vendor delivery to reduce warehousing and second destination charges, Federal Express provides the Air Force with 24-hour delivery of priority parts anywhere in the world, private contractors provide about 30 percent of DoD's depot-level maintenance and overhaul work. [Ref. 26]

Current doctrine plans for most of these contracts and activities to be executed during a time of increased conflict. However, as mentioned above, the scope of participation of civilians in combat support activities has increased. For example:

> During the Persian Gulf War in 1991, one [out] of every 50 people on the battlefield was an American civilian under contract; by the time of the peacekeeping effort in Bosnia in 1996, the figure was one in 10….contractors who perform tasks as mundane as maintaining barracks for

> overseas troops, as sophisticated as operating weapon systems or as secretive as intelligence-gathering in Africa. Many function near, or even at, the front lines [Ref. 57].

Does the fact that these activities are being performed by civilian contractors automatically make them “tail” or non-core activities? If that is the case, can the same activities be outsourced in any kind of conflict? Will these private companies continue to be committed once the conflict increases and their lives are at a stake? Will air, ground or maritime transport companies continue to risk their assets to deliver parts or personnel once they are declared military targets? Will insurance companies provide medical services if the conflict escalates and their monetary risk grows accordingly? Will private companies maintain the surge capabilities needed for wartime operations?

These questions may not currently have a clear answer. But, what is clear is that some activities considered non-core or “tail” in one instance and under a certain type of conflict must definitely be reassessed as core or “tooth” activities when the timing or the characteristics of the conflict change.

## C. TTR BASED ON AN OUTPUT/OUTCOMES MEASUREMENT SYSTEM

Most private companies measure outputs and calculate whether the value derived from an investment is worth the expenditure. Lately, there is a clear trend in both public and private organizations toward focusing on timely and meaningful outputs and outcomes (or impacts) of their investments over just inputs and processes.

Today, organizations' monitoring and reporting structures cover aspects like financial performance, physical productivity, quality of service, and effectiveness of operations through the following [Ref. 40]:

- Inputs: how many resources are allocated to programs, in what amounts and at what times.
- Outputs: the results achieved in relation to the resources spent (financial and non-financial, partial and comprehensive).
- Outcomes: the expected result, the ultimate reason for the program (qualitative and quantitative).

Up to this point, all the methods analyzed in this research use two basic criteria to determine whether a cost becomes part of DoD's "tooth" or "tail:" the position inside the organizational structure, or the geographical location of the unit, agency or activity that causes the cost. Based on the definitions above, these two criteria correspond to the inputs of the system.

A new approach for determining TTR would be to design a new budgeting system based on outputs and outcomes, i.e. on the results obtained from the investment; instead of on an input-collected and functional system with information relevant only to where the money was invested. The focus on outputs/outcomes of this system will be aligned with the Government Performance and Review Act (GPRA) of 1993, "The focus of GPRA is to be on outcomes vice inputs…. This shift in focus is expected to yield more results-oriented approaches and instill confidence in the government." [Ref. 27, p. 53] In the corporate world, this new approach would be similar to value chain analysis with a subsequent breakdown of primary versus support activities. To implement this new approach it is necessary to define a set

of outputs, outcomes or core products, related to specific capabilities closely related to DoD's core competencies.

The foundations of this approach can be found in a Defense Science Board study:

> Today, the Department's PPBS process and fiscal functions are at best a poorly structured ledger entry and journal-oriented accounting system. It knows the cost of countless disconnected and unrelated pieces (program elements) but not the value of the various purposes of the enterprise. This state of affairs results from the Department's focus on "inputs" versus "outputs…." For example, the Department can point to any number of program element codes associated with tactical systems, but it cannot evaluate the price of tactical operations—it does not think that way, nor does it set up and aggregate program accounts in that fashion. Nor does the Department possess the means to measure progress toward achieving any objectives. The current Defense Planning Guidance does not specify objectives or priorities, nor do the current Major Force Program categories in the PPBS process lend themselves to analysis by useful mission area. With no missions or objectives specified, the Department cannot measure meaningful 'outputs.'
>
> Several years ago, a Defense Science Board (DSB) study suggested that the Department set up an 'input-output' style resource table. Such a table would have the various DoD (military Service) organizations arrayed along the ordinate, and the various output organizations (CINCs) along the abscissa, with the right vertical column totaling to the overall DoD budget at the bottom…. [Ref. 49, p. 39]

In this case, the DSB assimilated outputs to Combatant Commands. However that is not the only possible approach, the outputs can be related to any level of stakeholders, as long as they are related to DoD's core competencies. As a

qualitative example, the following section employs an outputs/outcomes based measurement system to determine a TTR of the Special Operations Forces.

### 1. TTR of the Special Operations Forces (SOFs) Based on an Output and Outcomes Measurement System

Special Operations use small units in direct and indirect military actions, with combinations of specialized personnel, equipment, training, and tactics that go beyond the routine capabilities of conventional military forces. The U.S. Special Operations Command (USSOCOM) was created in 1987 to prepare and maintain combat-ready SOFs to successfully conduct all types of special operations [Ref. 56, p. 1]. USSOCOM, one of nine unified commands in the U.S. military's combatant command structure, is commanded by a four-star flag or general officer with the title of Commander, U.S. Special Operations Command (USCOMSOC). [Ref. 56, p. 45]

SOFs were selected to apply an outputs/outcomes based measurement system because USCOMSOC has two roles: in his function as a supporting Commander, he carries out many service-like responsibilities, including training, ensuring combat readiness, monitoring personnel promotions and assignments, and developing and acquiring SOFs-peculiar equipment; in his job as a supported Commander, he must command selected special operations missions when directed by the National Command Authority (NCA). [Ref. 56, p. 11]

The management of MFP-11 is also the responsibility of USSOCOM. As such, USCOMSOC is the sole unified commander with responsibility for planning, programming, and

budgeting military forces. In essence, he is the only Combatant Commander with a checkbook. [Ref. 56, p. 11]

#### *a) SOFs Missions, Collateral Activities and Organization*

The first step to create an output/outcome based system for determining what may be considered “tail” or “tooth,” is to ascertain the purpose or missions of the SOFs and USSOCOM.

Currently, SOFs have nine principal mission areas; they are also frequently tasked to participate in collateral activities that shift in response to the changing international environment. Although these tasks are not principal SOFs missions, they must be considered in a TTR analysis. The SOFs’ principal missions and collateral activities are listed in Table 7-1, and are further described in Appendix C. [Ref. 56, p. 4]

**Table 7-1, SOFs’ Principal Mission Areas and Collateral Activities [After Ref. 56, p. 4]**

| Principal Missions | Collateral Activities |
|---|---|
| Counterproliferation (CP) | Coalition support |
| Combating terrorism (CBT) | Combat search and rescue (CSAR) |
| Foreign internal defense (FID) | Counterdrug (CD) activities |
| Special reconnaissance (SR) | Humanitarian demining (HD) activities |
| Direct action (DA) | Humanitarian assistance (HA) |
| Psychological operations (PSYOP) | Security assistance (SA) |
| Civil affairs (CA) | Special activities |
| Unconventional warfare (UW) | |
| Information operations (IO) | |

USSOCOM’s mission is to support the geographic Combatant Commands, ambassadors and their country teams, and other government agencies by preparing SOFs to successfully conduct special operations, including Civil

Affairs (CA) and Psychological Operations (PSYOP). [Ref. 56, p. 11]

Figure 7-1 presents the USSOCOM organization. A detailed description of this organization, the basic functions, and force structure of each command or component, can be found in the year 2000 Posture Statement of the United States Special Operations Forces [Ref. 56]. The information is repeated in the Appendix C of this research to facilitate consultation by the reader.

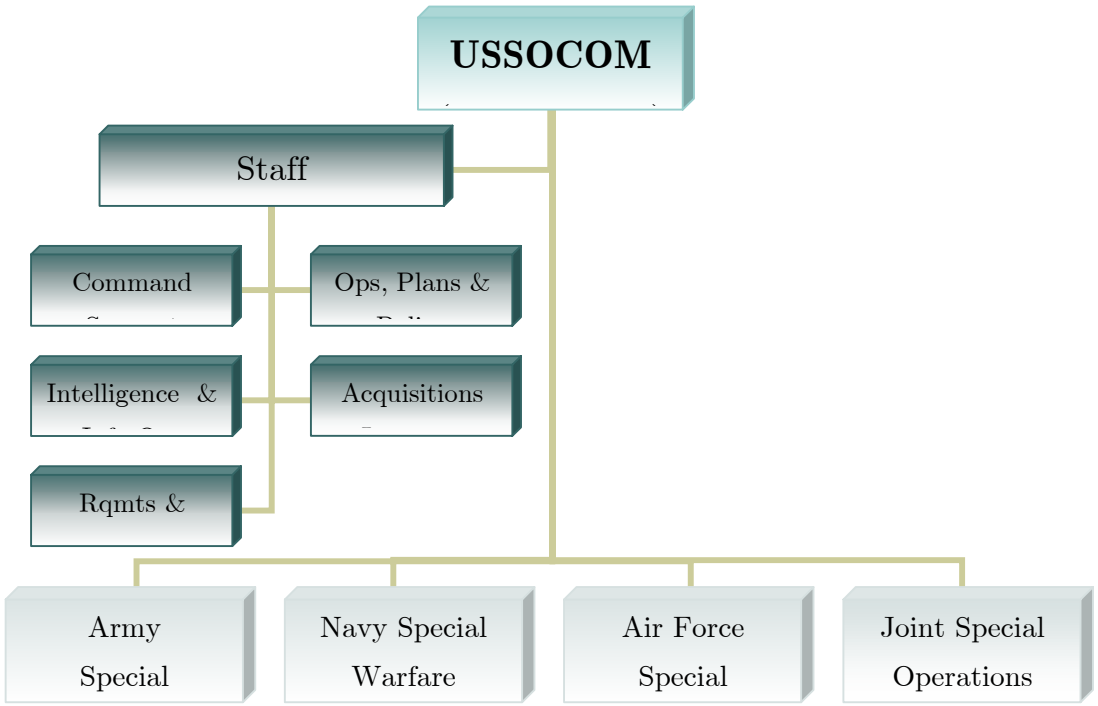


**Figure 7-1, USSOCOM Organization [After Ref. 56, p. 46]**

### *b) Defining the TTR of the SOFs According to Primary and Support Activities*

Figure 7-2 classifies and describes the relationships between the core competencies, core

competence, core products, and end products of the SOFs. The classification is based on Prahalad and Hamel [Ref. 35], and on the structure, principal missions and collateral activities of the SOFs described in the previous section.

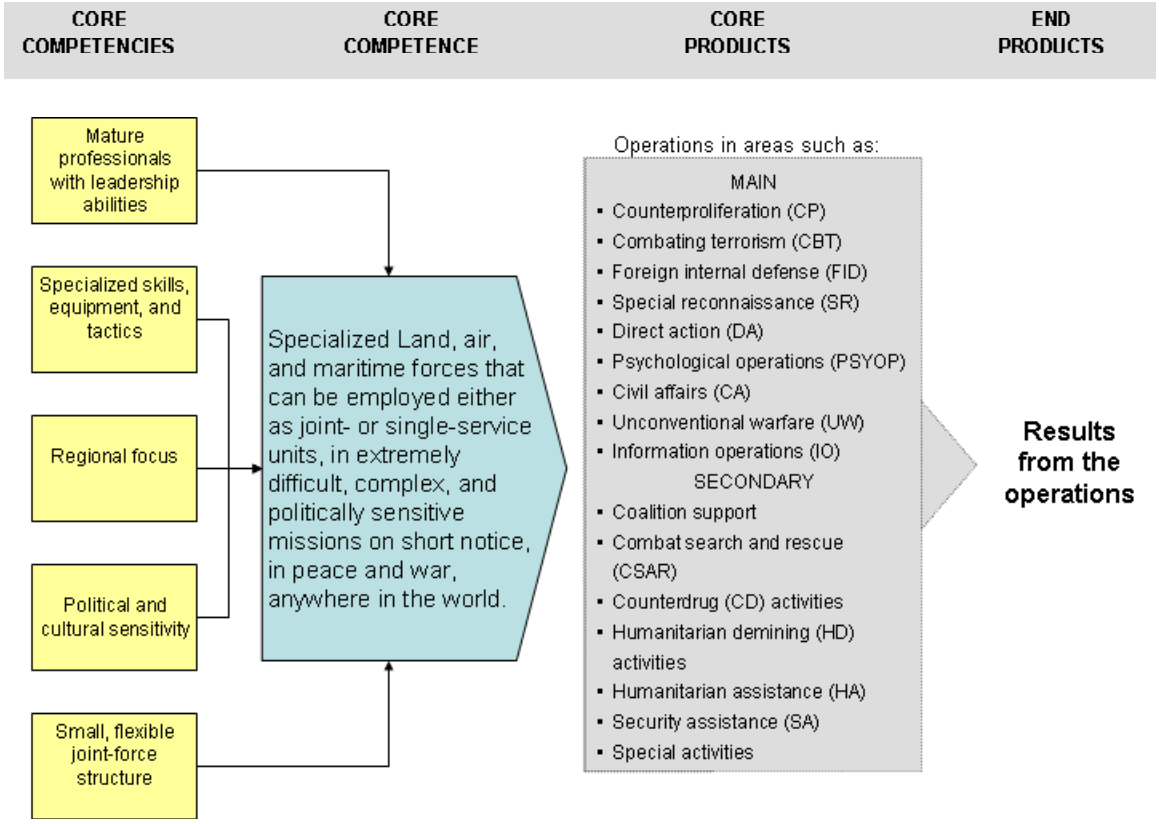


**Figure 7-2, Core Competencies and Products of the SOFs**

From Chapter VI, the SOFs' primary activities are those that directly create, deliver and service the core products shown in Figure 7-2, while the activities that allow those primary activities to be performed are the support activities. Table 7-2 gives an example of what occurs when the SOFs TTR is defined using primary and support activities according to the definitions outlined in Chapter VI, Section B.3.

**Table 7-2, Example of Defining the SOFs TTR Using Primary and Support Activities**

| Commands and Components | Functional Activities | Primary vs. support activities on outputs/outcomes system | |
|---|---|---|---|
| | | **Primary** | **Support** |
| **USCOMSOC** | Commands special missions | Service | |
| | Top-management | | Administration |
| **SOAL** | R&D | | Technology Development |
| | Acquisition | Inbound Logistics | |
| | | | Procurement |
| | Program management | | Procurement |
| | Logistics support | In/Outbound Logistics | |
| **SORR** | Force structure analysis | | Technology Development |
| | Strategic assessments | | Administration |
| | Requirements review | | Technology Development |
| **SORR** | War-gaming and simulation | Operations | |
| | Resources management | | Administration |
| | Comptroller | | Administration |
| **SOOP** | Oversees: Operations, doctrine, education, tempo, and training | | Administration |
| | Develops: plans & policy and force structure | | Administration |
| | Directs: deployments and employment of SOFs | Operations | |
| **SOIO** | Provides for information management in intelligence and communications | Operations | |
| | Develops special operations C4ISR and IO training, doctrine, and procedures | | Technology Develop. |
| **SOCS** | Provides personnel and special staff support to the headquarters and its components | | HR management |

| Commands and Components | Functional Activities | Primary vs. support activities on outputs/outcomes system | |
|---|---|---|---|
| | | **Primary** | **Support** |
| **Service Components** | Combat ready forces | Service | |
| **Joint Special Operations Command** | Ensure: interoperability and equipment standardization | | Technology Develop. |
| | Plans and conduct: exercises and training | Operations | |
| | Develops: joint tactics | | Technology Develop. |
| **Theater Special Operations Commands** | Plans and conduct special operations in the theater | Service | |

The main advantage of this approach resides in its inherent focus on core competencies and core products, which could provide a more realistic approximation of TTR. It may also facilitate evaluating the true costs of operations, of executing the various DoD tasks, and of achieving specific DoD objectives. [Ref. 49, p. 39]

The main disadvantage, as with all the other methods previously discussed, is that this approach tries to establish a well-defined boundary between “tail” and “tooth.” It is unrealistic to define such a line. For example, Table 7-2 looks at the SOFs organization as an autonomous entity; by changing the level of the analysis to a more macro or micro level, the definitions of primary and support activities also change.

Additionally, it would be necessary to take into account the costs associated with the unavoidable change to DoD’s budgeting system. If the only objective of that change is to find a better definition of the TTR, it would

not be a justifiable investment from a cost-benefit perspective.

## D. "TAIL" AND "TOOTH" AS A CONTINUUM

Chapters II and III of this research showed that, historically, the relationship between "tail" and "tooth" has been presented as a ratio or a percentage which implies determining two specific numbers for "tail" and "tooth." DoD's mandate by the US Code to report annually the appropriate ratio of combat forces to support forces has intensified the fixation on defining a clear-cut line between combat and support.

This research has shown that such a line is illusory. The boundary between "tail" and "tooth" behaves more as a wide, fuzzy, irregular band that fluctuates depending on the situation, the environment, and the timing. Consequently, the relationship between "tooth" and "tail" can no longer be considered a ratio or a mathematical relationship between two numbers, but more of a continuum.

In DoD, activities that can be considered "tail" in most circumstances (such as procurement of office supplies or janitorial services) are located at one end of this continuum. The other end of the continuum includes those activities that are unmistakably "tooth" (for example, an infantry soldier on the combat front, or a pilot and his aircraft on a combat mission). As for the rest of DoD commands, activities and processes, it is really a futile exercise to position them in a specific place on this continuum. Only when given a specific mission, time, and circumstances, will it be possible to position the varied

DoD activities onto this continuum. Figure 7-3 graphically depicts this new concept.

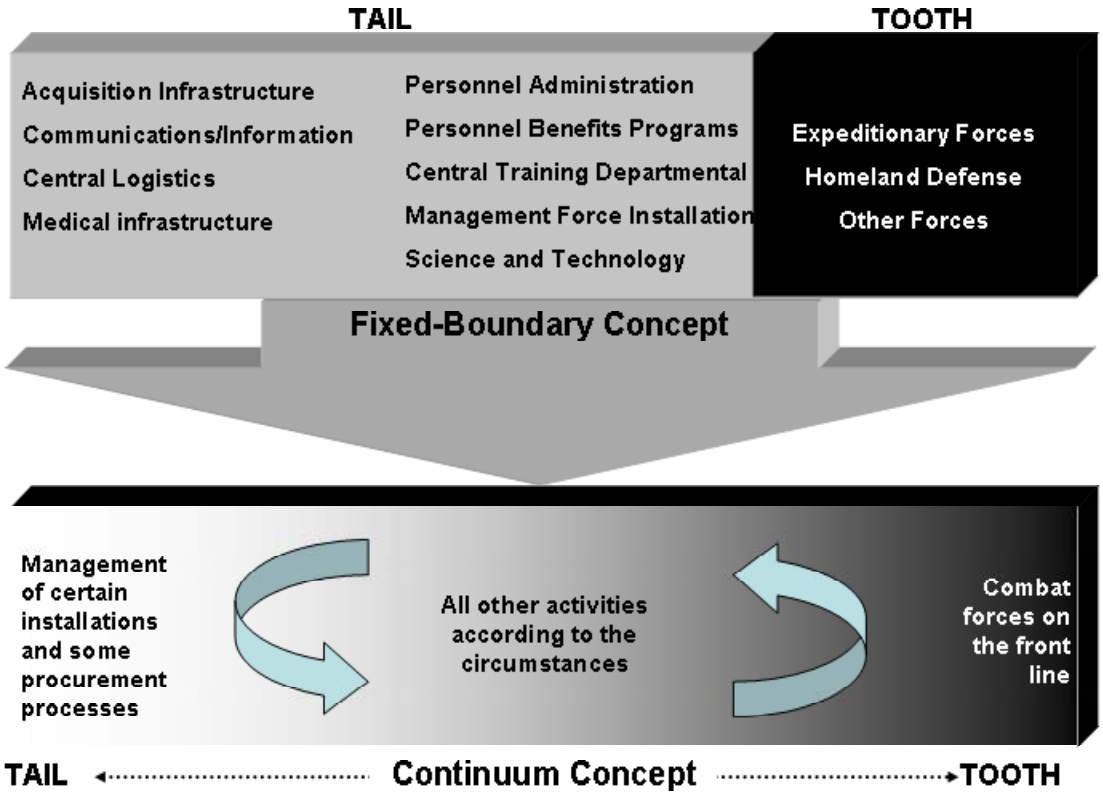


**Figure 7-3, From a Fixed-Boundary to a Continuum Concept**

The notion of a one-dimensional continuum can be expanded to two dimensions. For example, the location of an activity on the "Tail to Tooth Continuum" (TTC) at a given moment can be approximated by the activity's correlation with the core product, and the current threat in a specified conflict. The larger the correlation between the activity and the core product, and the higher the threat or conflict level, the closer that activity will be to the "tooth" on the two dimensional TTC.

In the case of the SOFs, a Deployable Print Production Center (DPPC) for creating, editing, and producing PSYOP

print products in forward-deployed locations may be close to the “tail” if the core product is combating terrorism, but it will certainly be closer to the “tooth” quadrant, if the main mission is in psychological operations. Figure 7-4 illustrates this example.

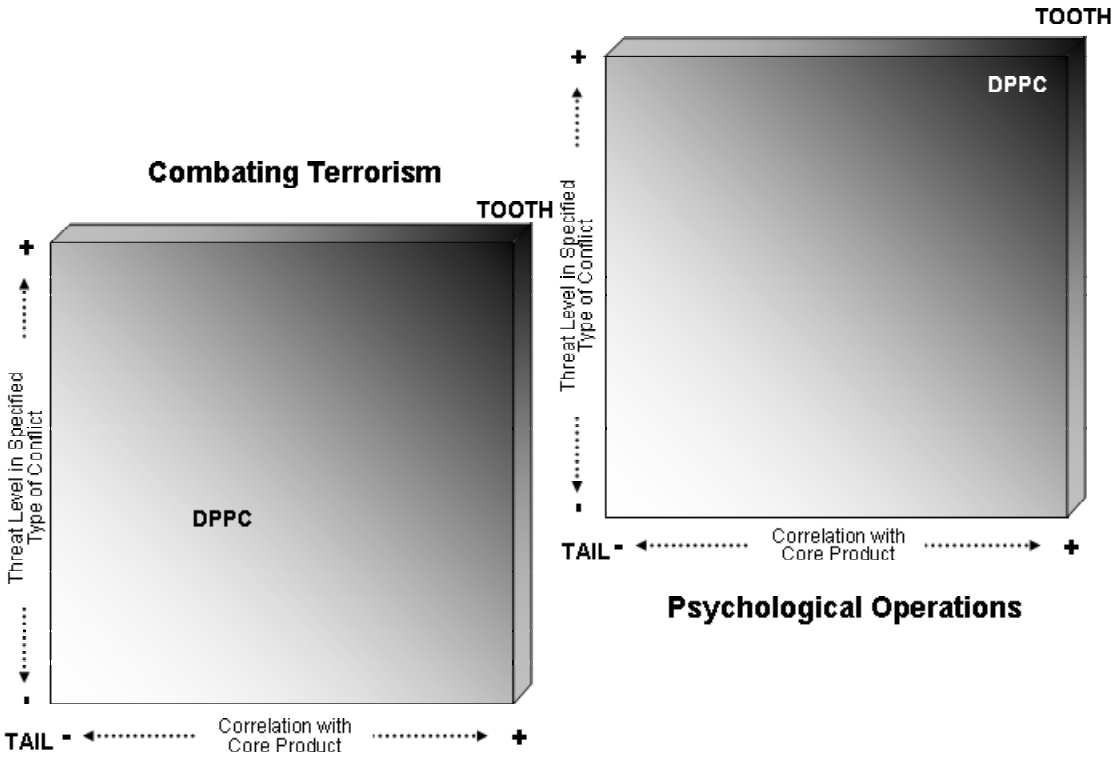


**Figure 7-4, Example of Locating a SOFs Unit on a Two Dimensional “Tail to Tooth Continuum”**

Extrapolating the same argument for moving from one to two dimensions, argues that a three dimensional continuum could provide a better understanding of how to locate a specific activity between “tooth” and “tail.”

Figure 7-5 shows how the third dimension could be used to validate the core product’s relevance to the desired end result in a specified circumstance; the higher the activity’s relevance the closer it will be to the “tooth”

quadrant. An interesting conundrum arises when one activity simultaneously supports different core products. For example, SOFs combating terrorism and conducting psychological operations would be located in separate layers of the three dimensional TTC; but in a specified operation the same DPPC can support both core products simultaneously - this further illustrates the impossibility of defining a clear limit between “tail” and “tooth.”

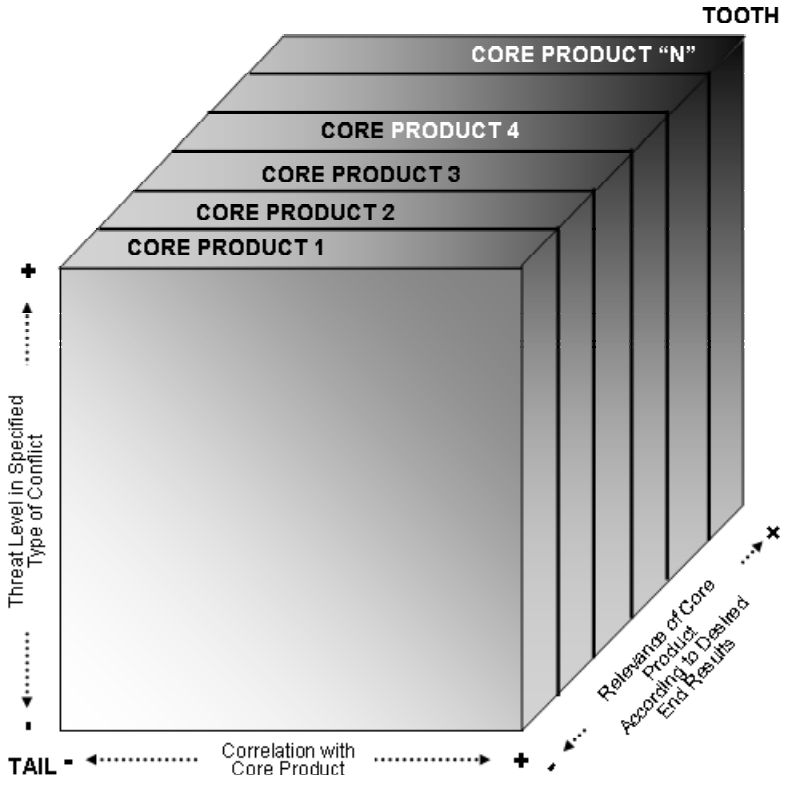


**Figure 7-5, Three Dimensional “Tail to Tooth Continuum”**

This approach does not imply that DoD, nor any other organization, should neglect developing its core competencies. The advantage of this approach is that it avoids the fruitless labeling of costs, allowing management to concentrate on increasing efficiency and reducing the

total costs of attaining DoD's desired outcomes. It may also help to avoid situations as described by Woodward:

> 'We haven't done a very precise job of describing … the differences between tooth and tail,' Air Force Gen. Richard Myers, chairman of the Joint Chiefs of Staff, said during a Pentagon round-table briefing Nov. 12. Myers was referring to the departmental jargon that distinguishes military commanders and combat forces — the tooth — from DoD overhead and support personnel — the tail.
>
> 'There's a lot of what we call tail that we can't go to war without,' Myers continued. This was not taken into account 'when we implemented the cuts.'
>
> Congress in its 2000 Defense Authorization Act ordered DoD to trim 15 percent of its headquarters staffs by the end of 2002. The last '7.5 percent [reduction] was supposed to happen this year,' Myers said. He added that 'we're working very hard here in Washington and with our combatant commands to see if adjustments are justified.'
>
> Defense Secretary Donald Rumsfeld echoed Myers' concerns by noting that 'we do not want to reduce [staff] levels to the point that we damage our effectiveness from a military standpoint.' Nevertheless, he emphasized that DoD would continue its efforts to move 'military people out of nonmilitary tasks' that can be better performed 'by civilians and contractors.' [Ref. 58]

## E. CHAPTER SUMMARY

The concept of an unambiguous boundary between "tail" and "tooth" was investigated in this chapter. Specific examples were used to demonstrate that a clear-cut line does not exist. On the contrary, the definitions of "tail"

and “tooth” change with the specific situation, the environment and the timing of the measurement.

The possibility of a new approach based on a new budgeting system, centered on outputs and outcomes instead of inputs, was presented. This method was used in a qualitative example to calculate the TTR of the Special Operations Forces. While this approach identifies several advantages, such as its inherent focus on core competencies and core products, and the feasibility of evaluating the true costs of operations, it is not without weaknesses. Its main weakness is that it is based on establishing a definite boundary between “tail” and “tooth” similar to the other methods.

A more appropriate measure was theorized based on the fact that the relationship between “tooth” and “tail” can no longer be considered a ratio or a mathematical relationship between two numbers, but a continuum. In this continuum, activities considered “tail” in most circumstances (e.g. procurement of office supplies or janitorial services) are located on one end, and activities unmistakably considered “tooth” (e.g. an infantry soldier on the combat front, or a pilot and his aircraft on a combat mission) are located on the other end. The other DoD commands, activities and processes can only be approximated on this continuum according to specific missions, times and circumstances. This one dimensional “Tail to Tooth Continuum” was further expanded to two and then three dimensions, according to the activity’s level of correlation with the core product, the current level of threat in a specified type of conflict, and finally the

relevance of the core product to the desired end result in an explicit circumstance.

THIS PAGE INTENTIONALLY LEFT BLANK

# VIII. CONCLUSIONS AND RECOMMENDATIONS

## A. INTRODUCTION

This research determined the key factors involved in calculating the Tail to Tooth Ratio (TTR), and analyzed the influence that the current top management intent on decreasing the TTR has had on the United States Department of Defense (DoD) operational readiness and expenditure efficiency. This was accomplished by analyzing documents and publications from DoD, Congress, and diverse organizations; examining concepts, testimonies, speeches, statements, and interviews released by top DoD management and Service leaders; and using specific DoD activities and programs as examples to demonstrate several theories and findings.

This chapter summarizes the research findings, answers the research questions and presents some areas for further research.

## B. SUMMARY OF RESEARCH FINDINGS

The TTR expresses the relationship between the resources or forces employed to perform the core missions and the resources or infrastructure used to manage and support those forces. The Goldwater-Nichols Act of 1986 establishes a demarcation line between forces and infrastructure. The definitions of tooth and tail as assumed by DoD from this law are, TOOTH: military units assigned to combatant commands, and TAIL: administration and force support activities assigned by the Secretary of

Defense to the military departments, the Defense Agencies, civilian contractors or in some special cases combatant commands.

There are three different approaches to the definition of TTR:

1) Comparing the dollars that are allocated to the combat or fighting capability (tooth), and the dollars that are allocated to everything else (tail). This approach, in turn, uses two methods to determine the TTR: the Force Structure vs. Infrastructure method and the Major Force Programs and Appropriation Codes method;

2) Comparing the relationship between the people involved in combat and the people involved in support activities; and

3) A separate TTR for specific procurement programs or projects.

Due to the corporate world's focus on profits, it is easier to decipher what is "tooth" and what is "tail" within this environment than in DoD. However, even with this steady focus on profitability, disagreements still arise amongst business leaders regarding how "tooth" and "tail" should be measured. Several methods are used, including absorption costing, variable costing, activity based costing and value chain analysis. Due to the intangible nature of DoD's bottom line, it has become increasingly difficult to define the boundaries between "tooth" and "tail."

All of the methods used in DoD to measure the TTR attempt to establish an unambiguous boundary between "tail"

and “tooth.” Specific cases and examples confirm that such a clear-cut limit does not exist. On the contrary, the definitions of “tail” and “tooth” change with the specific situation, the environment and the timing of the measurement.

A new approach based on a new budgeting system, centered on outputs and outcomes instead of inputs, has several advantages, including: its inherent focus on core competencies and core products, and the feasibility of evaluating the true costs of operations. However, it is not without weaknesses; its main weakness is that it is based on establishing a definite boundary between “tail” and “tooth,” similar to the other methods.

Because the demarcation between “tail” and “tooth” is not fixed, their relationship should not be expressed as a ratio or a mathematical relationship between two numbers, but as a continuum. This “Tail to Tooth Continuum” was expanded to two and three dimensions, according to the activity’s correlation with the core product, the current threat level in a specified type of conflict, and finally the relevance of the core product to the desired end result in an explicit circumstance.

This approach does not imply that DoD, nor any other organization, should neglect its core competencies. The advantage of this approach is that it avoids the fruitless labeling of costs, allowing DoD management to concentrate on increasing efficiency and reducing the total costs of attaining DoD’s desired outcomes.

## C. ANSWERS TO RESEARCH QUESTIONS

**Primary research question: is the TTR an appropriate measure of operational readiness and military expenditure efficiency?**

The first attribute that a performance measure should have is objectivity. A measure is objective if it can be independently measured and verified. There should be little ambiguity about its meaning and the desired results. [Ref. 41, p. 235] This research has shown that such a line is illusory. The boundary between "tail" and "tooth" behaves more as a wide, fuzzy, irregular band that fluctuates depending on the situation, the environment, and the timing, making the TTR a completely subjective measure.

Performance goals serve to communicate strategy and to motivate people; they compel the workforce to perform in a desired way; as such, they must be aligned with the organizations objectives and goals. The demarcation line between forces and infrastructure established by the Goldwater-Nichols Act and the current DoD interpretations of TTR can produce incentives to eliminate costs understood as "tail," sometimes without the necessary cost-benefit studies to determine what is the most efficient approach.

**Secondary research question number 1: what elements should be considered "tail" or "tooth" in determining the TTR?**

The relationship between "tooth" and "tail" should not be considered as a ratio or a mathematical relationship between two numbers, but rather as a continuum. Activities that can be considered "tail" in most circumstances (such

as procurement of office supplies or janitorial services) are located at one end of this continuum. On the other end of the continuum will be those activities that are unmistakably considered “tooth” (for example, an infantry soldier on the combat front, or a pilot and his aircraft on a combat mission). Only with a specific mission, time, and circumstances, is it possible to approximate the position of the varied DoD activities onto this continuum.

This one dimensional “Tail to Tooth Continuum” was further expanded to two and then three dimensions, according to the activity’s level of correlation with the core product, the current level of threat in a specified type of conflict, and finally the relevance of the core product to the desired end result in an explicit circumstance.

**Secondary research question number 2: what factors have influenced the change of the TTR over the past centuries?**

The “combat vs. support personnel” approach shows that the TTR has varied during several periods of military history from very low percentages in the ancient armies, to almost 95% in the Roman Legions, back down to approximately 55% in DoD within the past five years. However, the armies that have been able to reach those low TTR levels accomplished them by using methods that go against modern rules of war, even to the point that they threatened the very population that they were defending and protecting.

In several cases, careful logistics planning or the introduction of new technology was responsible for reducing the TTR. However, technology improvements and the

appearance of more complex systems and weapons created new logistical demands, and promoted the introduction of new organizations to create, manage, administer and support the vast forces needed for combat. All of these circumstances created an explosive increase in the number of organizations, agencies, staffs, and personnel in the U.S. Armed Forces between 1915 and 1945.

**Secondary research question number 3: what is the effect of current technological advances on the TTR?**

History has shown that introducing and assimilating new military technologies and weapons, in some cases, reduced activities conventionally regarded as “tail.” However, when a weapon with a large increase in lethality is introduced, there is a corresponding increase in dispersion or a reduction in some force program (i.e. reduction in the “tooth”); and an increase in other activities generally considered as “tail.” The important issue regarding technological advances must be how efficiently the “tail” supports the “tooth” to boost the combat capabilities of the force and not whether the investment should be classified as “tail” or “tooth.”

In general, technology has reduced the number of soldiers on the combat front per unit of area needed to obtain a specific level of lethality or a required level of deterrence. Specifically, in the case of the US vision for future warfare, where unmanned vehicles are one of the approaches being considered, these programs will certainly reduce some activities considered “tail;” but most of the cost reductions will be in categories normally regarded as

“tooth,” especially in flying crews and operational training costs.

**Secondary research question number 4: is there a direct relationship between operational readiness and TTR?**

Many studies call for reducing the “tail” with the ultimate objective of applying the realized savings to the “tooth” to sustain adequate levels of readiness. However, in the case of the operational readiness of a weapon system - defined in this research as its operational availability - increasing the inventory (“tooth”) is only one possible way to improve readiness, sometimes increasing the depot level maintenance and/or the administrative/logistics capabilities (“tail”) may be better alternatives.

The economic theory of diminishing marginal utility or returns is applicable in this case. As the amount of “tooth” is increased, holding all other inputs constant, the amount that readiness increases for each additional unit of “tooth” will generally decrease. Thus, in every case a cost-benefit analysis should be used to determine the best method to reduce costs while also improving readiness.

The design of the maintenance and repair processes of an acquisition program can influence the total LCC of the system. Organizational and intermediate level maintenance are not always more cost-effective than depot level maintenance. Contrary to the widely accepted belief that the key to efficiency lies in eliminating the “tail,” increases in the “tail” often lead to reductions in total LCC.

**Secondary research question number 5: should DoD continue to pursue a reduction in the "tail" of all its programs?**

DoD should continue to pursue cost reductions in all of its programs and activities. William J. McCord, founder of the McCord consulting group on lean thinking, aptly stated that "businesses are much like a three-legged stool, with legs consisting of Process, People, and Technology. Ignore one of these legs, and the entire stool falls." [Ref. 25] DoD should not place too much emphasis on labeling costs but instead should concentrate on applicable "best business" practices, that increase efficiency and reduce the total costs of attaining DoD's desired outcomes. It is important to note that not all "best business" practices are directly transferable from the corporate world to DoD.

A common misnomer in today's society is that "tooth" is more important than "tail." However, from an anatomical perspective using the Tyrannosaurus, one of the biggest meat eating dinosaurs, as an example; it is clear to see that both "tooth" and "tail" play a major role in operating efficiency. "The Tyrannosaurus… had powerful jaws, with sharp 7 inch teeth, well designed for eating other dinosaurs. It could use its long tail for balance when attacking other dinosaurs." [Ref. 22]

This same concept is well summarized by SecDef Donald Rumsfeld "we do not want to reduce [staff] levels to the point that we damage our effectiveness from a military standpoint;" and Air Force Gen. Richard Myers, Chairman of

the Joint Chiefs of Staff "there’s a lot of what we call tail that we can’t go to war without." [Ref. 58]

## D. AREAS OF FURTHER RESEARCH

This thesis developed a new concept, “Tail to Tooth Continuum” for evaluating which assets are “tooth” and which are “tail.” The QDR requires that DoD provide a ratio of combat forces to support forces. Future research could examine the application of this new concept to the existing MFP structure, to provide a less subjective measure of TTR.

Another area of possible research is to redesign the mission/force categories and infrastructure categories using the “Tail to Tooth Continuum” concept.

THIS PAGE INTENTIONALLY LEFT BLANK

# APPENDIX A

**Table A - 1, Department of Defense TOA by Force and Infrastructure Categories**
**(FY 2003 $ in Billions)**

| CATEGORY | FY 1998 | FY 1999 | FY 2000 | FY 2001 | FY 2002 |
|---|---|---|---|---|---|
| **Forces** | | | | | |
| Expeditionary Forces | 124 | 127 | 129 | 135 | 137 |
| Homeland Defense Forces | 7 | 8 | 8 | 9 | 13 |
| Other Forces | 29 | 30 | 29 | 31 | 33 |
| Defense Emergency Response Fund | - | - | - | - | 16 |
| **Forces Total** | **160** | **166** | **166** | **175** | **199** |
| **Infrastructure** | | | | | |
| Force Installations | 20 | 21 | 23 | 23 | 25 |
| Communications & Information | 4 | 4 | 4 | 5 | 5 |
| Science & Technology Program | 9 | 8 | 9 | 9 | 10 |
| Acquisition | 8 | 8 | 9 | 9 | 8 |
| Central Logistics | 17 | 17 | 20 | 18 | 19 |
| Defense Health Program | 19 | 18 | 19 | 22 | 25 |
| Central Personnel Administration | 10 | 9 | 10 | 10 | 10 |
| Central Personnel Benefits Programs | 8 | 8 | 8 | 8 | 9 |
| Central Training | 24 | 24 | 25 | 25 | 27 |
| Departmental Management | 15 | 16 | 15 | 15 | 14 |
| Other Infrastructure | 3 | 3 | 4 | 4 | 4 |
| **Infrastructure Total** | **136** | **138** | **145** | **148** | **154** |
| **Grand Total** | **295** | **304** | **311** | **323** | **353** |
| Infrastructure as a % of total budget | 46% | 45% | 47% | 46% | 44% |
| Infrastructure as a % of total budget when the DWCF portion of the infrastructure funded by mission programs is estimated as 25% of the total infrastructure. (GAO approach) | 60% | 59% | 61% | 60% | 57% |
| Infrastructure as % of total budget when all DWCF orders (as reported by the DoD comptroller in Table A-4) are included as infrastructure. | 53% | 52% | 53% | 52% | 50% |
| Infrastructure as % of total budget when DWCF orders (as reported by the DoD comptroller in Table A-4) are allocated between forces and infrastructure. | 50% | 49% | 50% | 49% | 47% |

After FY 2003 President's Budget and associated FYDP with Institute for Defense Analyses normalization adjustments.

**Table A - 2, Department of Defense TOA by Major Force Programs Assuming 6 MFPs as "Combat Forces Programs"**
**(FY 2003 $ in Billions)**

| Major Force Program | FY 1998 | FY 1999 | FY 2000 | FY 2001 | FY 2002 |
|---|---|---|---|---|---|
| **Combat Forces Programs** | | | | | |
| Strategic Forces | 8 | 8 | 8 | 7 | 8 |
| General Purpose Forces | 104 | 109 | 111 | 120 | 121 |
| C3I & Space | 34 | 35 | 37 | 38 | 39 |
| Mobility Forces | 12 | 13 | 13 | 11 | 12 |
| Guard & Reserve Forces | 25 | 26 | 25 | 26 | 27 |
| Special Operations Forces | 4 | 4 | 4 | 3 | 4 |
| **Combat Forces Programs Total** | **186** | **194** | **198** | **206** | **212** |
| **Infrastructure** | | | | | |
| Research & Development | 29 | 29 | 30 | 31 | 36 |
| Central Supply & Maintenance | 18 | 19 | 22 | 20 | 21 |
| Training Medical & Other GP Activities | 52 | 51 | 52 | 56 | 59 |
| Administration & Associates Activities | 9 | 9 | 9 | 9 | 25 |
| Support to Other Nations | 1 | 1 | 1 | 1 | 1 |
| **Infrastructure Total** | **109** | **109** | **114** | **117** | **141** |
| **Grand Total** | **295** | **304** | **311** | **323** | **353** |
| Infrastructure as a % of total budget | 37% | 36% | 37% | 36% | 40% |
| Infrastructure as a % of total budget when the DWCF portion of the infrastructure funded by mission programs is estimated as 20% to 25% of the total infrastructure. (GAO approach) | 48% | 47% | 48% | 47% | 52% |
| Infrastructure as % of total budget when all DWCF orders (as reported by the DoD comptroller in Table A-4) are included as infrastructure. | 43% | 42% | 43% | 43% | 46% |
| Infrastructure as % of total budget when DWCF orders (as reported by the DoD comptroller in Table A-4) are allocated between forces and infrastructure. | 41% | 40% | 40% | 40% | 44% |

After National Defense Budgets Estimates for FY 2003

**Table A - 3, Department of Defense TOA by Major Force Programs Assuming only 3 MFPs as "Combat Forces Programs"**
**(FY 2003 $ in Billions)**

| Major Force Program | FY 1998 | FY 1999 | FY 2000 | FY 2001 | FY 2002 |
|---|---|---|---|---|---|
| **Combat Forces Programs** | | | | | |
| Strategic Forces | 8 | 8 | 8 | 7 | 8 |
| General Purpose Forces | 104 | 109 | 111 | 120 | 121 |
| Special Operations Forces | 4 | 4 | 4 | 3 | 4 |
| **Combat Forces Programs Total** | **116** | **120** | **123** | **131** | **133** |
| **Infrastructure** | | | | | |
| C3I & Space | 34 | 35 | 37 | 38 | 39 |
| Mobility Forces | 12 | 13 | 13 | 11 | 12 |
| Guard & Reserve Forces | 25 | 26 | 25 | 26 | 27 |
| Research & Development | 29 | 29 | 30 | 31 | 36 |
| Central Supply & Maintenance | 18 | 19 | 22 | 20 | 21 |
| Training Medical & Other GP Activities | 52 | 51 | 52 | 56 | 59 |
| Administration & Associates Activities | 9 | 9 | 9 | 9 | 25 |
| Support to Other Nations | 1 | 1 | 1 | 1 | 1 |
| **Infrastructure Total** | **179** | **184** | **188** | **193** | **220** |
| **Grand Total** | **295** | **304** | **311** | **323** | **353** |
| Infrastructure as a % of total budget | 61% | 60% | 61% | 60% | 62% |
| Infrastructure as a % of total budget when the DWCF portion of the infrastructure funded by mission programs is estimated as 20% to 25% of the total infrastructure. (GAO approach) | 79% | 79% | 79% | 77% | 81% |
| Infrastructure as % of total budget when all DWCF orders (as reported by the DoD comptroller in Table A-4) are included as infrastructure. | 67% | 67% | 67% | 66% | 68% |
| Infrastructure as % of total budget when DWCF orders (as reported by the DoD comptroller in Table A-4) are allocated between forces and infrastructure. | 61% | 61% | 61% | 60% | 63% |

After National Defense Budgets Estimates for FY 2003

**Table A - 4, Defense-Wide Working Capital Fund FY 2003 Budget Estimates, Orders from DoD Components (FY 2003 $ in Millions)**

| Service or Agency | FY 2001 | FY 2002 | FY 2003 |
|---|---|---|---|
| Army | 4,284.2 | 4,411.6 | 4,344.8 |
| Navy | 5,260.7 | 5,405.2 | 5,199.6 |
| Air Force | 6,172.2 | 6,523.8 | 6,100.5 |
| Marine Corps | 563.1 | 604.1 | 613.7 |
| Other | 1,967.0 | 1,549.9 | 1,705.6 |
| Orders from Other Fund Activity Groups | 2,443.1 | 2,663.4 | 2,825.5 |
| **Total DoD** | **20,690.3** | **21,158.0** | **20,789.7** |

After http://www.dtic.mil/comptroller/fy2003budget

**Table A - 5, Department of Defense Active-Duty Military and Civilian Manpower by Force and Infrastructure Categories (in thousands)**

| CATEGORY | FY 1998 | FY 1999 | FY 2000 | FY 2001 | FY 2002 |
|---|---|---|---|---|---|
| **Forces** | | | | | |
| Expeditionary Forces | 800 | 788 | 796 | 804 | 826 |
| Homeland Defense Forces | 31 | 30 | 29 | 28 | 29 |
| Other Forces | 61 | 60 | 59 | 60 | 66 |
| **Forces Total** | **893** | **878** | **884** | **892** | **921** |
| **Infrastructure** | | | | | |
| Force Installations | 188 | 186 | 173 | 171 | 157 |
| Communications & Information | 29 | 28 | 24 | 25 | 24 |
| Science & Technology Program | 17 | 16 | 15 | 15 | 16 |
| Acquisition | 110 | 105 | 98 | 97 | 98 |
| Central Logistics | 204 | 189 | 182 | 176 | 174 |
| Defense Health Program | 142 | 134 | 127 | 129 | 130 |
| Central Personnel Administration | 86 | 64 | 91 | 93 | 86 |
| Central Personnel Benefits Programs | 48 | 48 | 48 | 49 | 48 |
| Central Training | 297 | 316 | 298 | 298 | 273 |
| Departmental Management | 123 | 124 | 119 | 117 | 116 |
| Other Infrastructure | 19 | 15 | 22 | 12 | 18 |
| **Infrastructure Total** | **1,262** | **1,227** | **1,198** | **1,182** | **1,140** |
| **Grand Total** | **2,155** | **2,105** | **2,082** | **2,074** | **2,061** |
| Infrastructure as a % of total manpower | 59% | 58% | 58% | 57% | 55% |

After FY 2003 President's Budget and associated FYDP with Institute for Defense Analyses normalization adjustments.
NOTE: Excludes National Guard and Reserve personnel.

**Table A - 6, Active-Duty Military and Civilian Manpower by Services and by Force and Infrastructure Categories (in thousands)**

| CATEGORY | FY 1998 | FY 1999 | FY 2000 | FY 2001 | FY 2002 |
|---|---|---|---|---|---|
| **Army** | | | | | |
| Forces | 354 | 347 | 352 | 358 | 363 |
| Infrastructure | 367 | 359 | 352 | 342 | 333 |
| Total Army | 722 | 706 | 704 | 700 | 696 |
| Infrastructure as % of Total | 51% | 51% | 50% | 49% | 48% |
| **Navy** | | | | | |
| Forces | 199 | 194 | 196 | 200 | 208 |
| Infrastructure | 373 | 362 | 354 | 351 | 333 |
| Total Navy | 572 | 556 | 549 | 551 | 542 |
| Infrastructure as % of Total | 65% | 65% | 64% | 64% | 62% |
| **Air Force** | | | | | |
| Forces | 221 | 219 | 215 | 212 | 227 |
| Infrastructure | 321 | 310 | 304 | 304 | 291 |
| Total Air Force | 542 | 529 | 518 | 516 | 518 |
| Infrastructure as % of Total | 59% | 59% | 59% | 59% | 56% |
| **Marine Corps** | | | | | |
| Forces | 107 | 107 | 111 | 110 | 110 |
| Infrastructure | 87 | 87 | 83 | 83 | 82 |
| Total Marine Corps | 194 | 193 | 194 | 193 | 192 |
| Infrastructure as % of Total | 45% | 45% | 43% | 43% | 43% |
| **Defense Agency and Defense-Wide** | | | | | |
| Forces | 11 | 11 | 11 | 11 | 12 |
| Infrastructure | 114 | 109 | 105 | 103 | 101 |
| Total Defense Agency and DW | 126 | 120 | 116 | 113 | 112 |
| Infrastructure as % of Total | 91% | 91% | 91% | 90% | 90% |
| **Grand Total** | **2,155** | **2,105** | **2,082** | **2,074** | **2,061** |

After FY 2003 President's Budget and associated FYDP with Institute for Defense Analyses normalization adjustments.
NOTE: Excludes National Guard and Reserve personnel.

THIS PAGE INTENTIONALLY LEFT BLANK

# APPENDIX B

## Table B - 1, Comparative Operational Lethality Indices

| Historical Period | | Ancient or Medieval | 17th Cent | 18th Cent | Nap. Wars | Civil War | WW I | WW II | 1975 |
|---|---|---|---|---|---|---|---|---|---|
| **Dispersion Factor** | | **1** | **5** | **10** | **20** | **25** | **250** | **3000** | **4000** |
| **Weapons** | **TLI values** | **OLI Values** | | | | | | | |
| Hand-to-hand | 23 | 23 | 4.6 | 2.3 | 1.2 | 0.9 | 0.09 | 0.008 | 0.006 |
| Javelin | 19 | 19 | | | | | | | |
| Ordinary bow | 21 | 21 | | | | | | | |
| Longbow | 36 | 36 | 7.2 | 3.6 | | | | | |
| Crossbow | 33 | 33 | 6.6 | | | | | | |
| Arquebus | 10 | | 2.0 | | | | | | |
| 17th C musket | 19 | | 3.8 | | | | | | |
| 18th C flintlock | 43 | | 8.6 | 4.3 | 2.2 | 1.7 | | | |
| Early 19th C rifle | 36 | | | 3.6 | 1.8 | 1.4 | | | |
| Mid-19th C rifle | 102 | | | | | 4.1 | | | |
| Late 19th C rifle | 153 | | | | | 6.1 | 0.61 | 0.05 | |
| Springfield 1903 rifle | 495 | | | | | | 1.98 | 0.17 | 0.12 |
| WW I machine gun | 3,463 | | | | | | 13.85 | 1.15 | 0.87 |
| WW II machine gun | 4,973 | | | | | | | 1.66 | 1.24 |
| 16th C 12-pdr cannon | 43 | 43 | 8.6 | | | | | | |
| 17th C 12-pdr cannon | 224 | | 44.8 | 22.4 | | | | | |
| Gribeauval 12-pdr cannon | 940 | | | 94.0 | 47.0 | 37.6 | | | |
| French 75mm gun | 386,530 | | | | | | 1546.1 | 128.8 | 96.6 |
| 155mm GPF | 912,428 | | | | | | 3,649.7 | 304.1 | 228.1 |
| 105mm Howitzer | 637,215 | | | | | | | 212.4 | 159.3 |
| 155mm “Long Tom” | 1,180,681 | | | | | | | 393.6 | 295.2 |
| WW I tank | 34,636 | | | | | | 138.5 | 11.5 | |
| WW II medium tank | 935,458 | | | | | | | 311.8 | 233.9 |
| WW I fighter bomber | 31,909 | | | | | | 127.6 | 10.6 | |
| WW II fighter bomber | 1,245,789 | | | | | | | 415.3 | 311.4 |
| V-2 ballistic missile | 3,338,370 | | | | | | | 1,112.8 | 834.6 |
| 20KT nuclear airburst | 49,086,000 | | | | | | | 16,362.0 | 12,271.5 |
| One megaton nuclear airburst | 695,385,000 | | | | | | | 231,795.0 | 173,846.3 |

[After Ref. 9, Table 7, p. 313]

## Table B - 2, Normalized Comparative Operational Lethality Indices

| Historical Period | Ancient or Medieval | 17th Cent | 18th Cent | Nap. Wars | Civil War | WW I | WW II | 1975 |
|---|---|---|---|---|---|---|---|---|
| **Dispersion Factor** | **1** | **5** | **10** | **20** | **25** | **250** | **3000** | **4000** |
| **Weapons** | **Normalized OLI Values** | | | | | | | |
| Hand-to-hand | 4,000.0 | 800.0 | 400.0 | 200.0 | 160.0 | 16.0 | 1.3 | **1.0** |
| Javelin | 3,304.3 | | | | | | | |
| Ordinary bow | 3,652.2 | | | | | | | |
| Longbow | 6,260.9 | 1,252.2 | 626.1 | | | | | |
| Crossbow | 5,739.1 | 1,147.8 | | | | | | |
| Arquebus | | 347.8 | | | | | | |
| 17th C musket | | 660.9 | | | | | | |
| 18th C flintlock | | 1,495.7 | 747.8 | 373.9 | 299.1 | | | |
| Early 19th C rifle | | | 626.1 | 313.0 | 250.4 | | | |
| Mid-19th C rifle | | | | | 709.6 | | | |
| Late 19th C rifle | | | | | 1,064.3 | 106.4 | 8.9 | |
| Springfield 1903 rifle | | | | | | 344.3 | 28.7 | 21.5 |
| WW I machine gun | | | | | | 2,409.0 | 200.8 | 150.6 |
| WW II machine gun | | | | | | | 288.3 | 216.2 |
| 16th C 12-pdr cannon | 7,478.3 | 1,495.7 | | | | | | |
| 17th C 12-pdr cannon | | 7,791.3 | 3,895.7 | | | | | |
| Gribeauval 12-pdr cannon | | | 16,347.8 | 8,173.9 | 6,539.1 | | | |
| French 75mm gun | | | | | | 268,890.4 | 22,407.5 | 16,805.7 |
| 155mm GPF | | | | | | 634,732.5 | 52,894.4 | 39,670.8 |
| 105mm Howitzer | | | | | | | 36,940.0 | 27,705.0 |
| 155mm “Long Tom” | | | | | | | 68,445.3 | 51,334.0 |
| WW I tank | | | | | | 24,094.6 | 2,007.9 | |
| WW II medium tank | | | | | | | 54,229.4 | 40,672.1 |
| WW I fighter bomber | | | | | | 22,197.6 | 1,849.8 | |
| WW II fighter bomber | | | | | | | 72,219.7 | 54,164.7 |
| V-2 ballistic missile | | | | | | | 193,528.7 | 145,146.5 |
| 20KT nuclear airburst | | | | | | | 2,845,565.2 | 2,134,173.9 |
| One megaton nuclear airburst | | | | | | | 40,312,173.9 | 30,234,130.4 |

# APPENDIX C

**SOFs PRINCIPAL MISSIONS**

SOFs are organized, trained, and equipped specifically to accomplish their assigned roles, as described below, in nine mission areas:

1. Counterproliferation (CP) – combat proliferation of nuclear, biological, and chemical weapons across the full range of U.S. efforts, including the application of military power to protect U.S. forces and interests; intelligence collection and analysis; and support of diplomacy, arms control, and export controls. Accomplishment of these activities may require coordination with other U.S. government agencies

2. Combating terrorism (CBT) – preclude, preempt, and resolve terrorist actions throughout the entire threat spectrum, including antiterrorism (defensive measures taken to reduce vulnerability to terrorist acts) and counterterrorism (offensive measures taken to prevent, deter, and respond to terrorism), and resolve terrorist incidents when directed by the NCA or the appropriate unified commander or requested by the Services or other government agencies

3. Foreign internal defense (FID) – organize, train, advise, and assist host-nation military and paramilitary forces to enable these forces to free and protect their society from subversion, lawlessness, and insurgency

4. Special reconnaissance (SR) – conduct reconnaissance and surveillance actions to obtain or verify information concerning the capabilities, intentions, and activities of an actual or potential enemy or to secure data concerning characteristics of a particular area

5. Direct action (DA) – conduct short-duration strikes and other small-scale offensive actions to seize, destroy, capture, recover, or inflict damage on designated personnel or materiel

6. Psychological operations (PSYOP) – induce or reinforce foreign attitudes and behaviors favorable to the originator's objectives by conducting planned operations to convey selected information to foreign audiences to influence their emotions, motives, objective reasoning, and, ultimately, the behavior of foreign governments, organizations, groups, and individuals

7. Civil affairs (CA) – facilitate military operations and consolidate operational activities by assisting commanders in establishing, maintaining, influencing, or exploiting relationships between military forces and civil authorities, both governmental and non-governmental, and the civilian population in a friendly, neutral, or hostile area of operation

8. Unconventional warfare (UW) – organize, train, equip, advise, and assist indigenous and surrogate forces in military and paramilitary operations normally of long duration

9. Information operations (IO) – actions taken to achieve information superiority by affecting adversary information and information systems while defending one's own information and information systems

**SOFs COLLATERAL ACTIVITIES**

Based on their unique capabilities, SOFs are frequently tasked to participate in the following activities:

1. Coalition support – integrate coalition units into multinational military operations by training coalition partners on tactics and techniques and providing communications

2. Combat search and rescue (CSAR) – penetrate air defense systems and conduct joint air, ground, or sea operations deep within hostile or denied territory, at night or in adverse weather, to recover distressed personnel during wartime or contingency operations. SOFs are equipped and manned to perform CSAR in

support of SOFs missions only. SOFs perform CSAR in support of conventional forces on a case-by-case basis not to interfere with the readiness or operations of core SOFs missions.

3. Counterdrug (CD) activities – train host-nation CD forces and domestic law enforcement agencies on critical skills required to conduct individual and small-unit operations in order to detect, monitor, and interdict the cultivation, production, and trafficking of illicit drugs targeted for use in the United States

4. Humanitarian demining (HD) activities – reduce or eliminate the threat, to noncombatants and friendly military forces, posed by mines and other explosive devices by training host-nation personnel in their recognition, identification, marking, and safe destruction; provide instruction in program management, medical, and mine-awareness activities

5. Humanitarian assistance (HA) – provide assistance of limited scope and duration to supplement or complement the efforts of host-nation civil authorities or agencies to relieve or reduce the results of natural or manmade disasters or other endemic conditions such as human pain, disease, hunger, or deprivation that might present a serious threat to life or that can result in great damage to, or loss of, property

6. Security assistance (SA) – provide training assistance in support of legislated programs which provide U.S. defense articles, military training, and other defense-related services by grant, loan, credit, or cash sales in furtherance of national policies or objectives

7. Special activities – subject to limitations imposed by Executive Order and in conjunction with a presidential finding and congressional oversight, plan and conduct actions abroad in support of national foreign policy objectives so that the role of the U.S. government is not apparent or acknowledged publicly

## ORGANIZATION, FORCE STRUCTURE AND BASIC FUNCTIONS OF THE US SPECIAL OPERATION FORCES

The following paragraphs describe the organization, force structure and basic functions of the SOFs' different Commands, headquarters, Service Components and Joint Special Commands as presented in the year 2000 Posture Statement of the United States Special Operations Forces [Ref. 56]

### Commander in Chief US Special Operations Command

All SOFs of the Army, Navy, and Air Force, based in the United States, are under USCOMSOC's combatant command. USSOCOM's service component commands are the Army Special Operations Command, the Naval Special Warfare Command, and the Air Force Special Operations Command. The Joint Special Operations Command is a sub-unified command of USCOMSOC. [Ref. 56, p. 46]

USCOMSOC receives the support of the Army, Navy, and Air Force who provide qualified personnel, common equipment, base operations support, logistical sustainment, and core skills training. This support allows USCOMSOC to focus on SOFs-specific training and equipment, as well as the integration of SOFs into the entire range of military operations. [Ref. 56, p. 12]

### Headquarters, U.S. Special Operations Command (HQ USSOCOM)

USSOCOM headquarters staff is configured into five functional centers. The following sub-sections present a brief description of each center.

#### *Acquisition and Logistics (SOAL) Center*

The SOAL combines the acquisition and the logistics functions of the command (J-4). It provides

research, development, acquisition, and logistics support to USCOMSOC. The SOAL plans, directs, reviews, and evaluates materiel development, procurement, and sustainment for USSOCOM; conducts liaison with USSOCOM components to ensure operational requirements are met by developmental programs; develops and promulgates USSOCOM acquisition and logistics policies and procedures; and manages a select group of special operations-peculiar programs.

Benefits derived from this organization include:

- Cradle-to-grave management of SOFs-related systems
- Improved life-cycle cost management
- Portfolio and materiel management
- Elimination of organizational stove pipes or barriers to collaboration
- Worldwide logistic support of SOFs Special Operations

***Requirements and Resources (SORR) Center***

The SORR combines the planning (J-5 and J-7) and resourcing (J-8) functions, to include the USSOCOM Strategic Planning Process. The mission of the SORR is to support SOFs through the development of resourcing, operational mission and force structure analysis, strategic assessments, and requirements reviews.

***Operations, Plans, and Policy (SOOP) Center***

The SOOP combines the J-3 and the J-5 staffs to provide focused operational support in the areas of doctrine, plans, policy, operations, training, and special actions. Its mission is to ensure all special operations deployments and plans supporting the NCA, regional Combatant Commanders, and Ambassadors are tailored to

mission requirements, reflect current force capabilities, and are consistent with USCOMSOC Title 10 responsibilities and core missions. In support of these objectives, the SOOP oversees SOFs doctrine, education, tempo, and remediation, as well as the training and exercise programs, in order to optimize force readiness and SOFs relevance.

The SOOP also develops joint plans, policy, strategic assessments, and force structure, and directs deployment, employment, and readiness of approximately 46,000 Army, Navy, and Air Force SOFs worldwide, including sensitive special mission units; validates operational requirements; and manages training resources, humanitarian programs, joint training exercises, and operational testing.

***Intelligence and Information Operations (SOIO) Center***

The SOIO combines the J-2 and J-6 staff functions to provide for integrated information management in intelligence, communications, information protection, network management, and audio/ visual support. SOIO integrates command and control, communications, computer, intelligence, surveillance, and reconnaissance (C4ISR), and information operations (IO) to gain information superiority throughout the spectrum of engagement and conflict. The SOIO validates requirements and develops special operations C4ISR and IO training, doctrine, and procedures.

***Command Support (SOCS) Center***

Created from the remaining command functions, the SOCS is a process-oriented support center that provides personnel and special staff support to the headquarters and its components. The SOCS includes public affairs, executive

services, medical, chaplain, historian, equal opportunity, security, quality integration, engineering, protocol, headquarters command, and joint secretariat support services. The USSOCOM chief of staff directs the center.

**Service Components and Joint Special Commands**

***U.S. Army Special Operations Command (USASOC)***

The Army special operations forces (ARSOF) include active, Army National Guard, and U.S. Army Reserve forces consisting of Special Forces, Rangers, special operations aviation, civil affairs (CA), psychological operations (PSYOP), and combat- and service-support units.

***Naval Special Warfare Command (NAVSPECWARCOM)***

Naval Special Warfare (NSW) forces are organized to support naval and joint special operations within the theater unified command. These forces are organized, equipped, and trained to be highly mobile and quickly deployable.

***Air Force Special Operations Command (AFSOC)***

Air Force special operations forces (AFSOF) are equipped with highly specialized, fixed and rotary-wing aircraft. AFSOC’s provide: SOFs mobility, forward presence and engagement, precision employment/strike, and information operations.

***Joint Special Operations Command (JSOC)***

A joint headquarters designed to study special operations requirements and techniques; ensure interoperability and equipment standardization; plan and conduct special operations exercises and training; and develop joint special operations tactics.

**Theater Special Operations Commands**

The theater special operations commands (SOC), are responsible to the geographic Combatant Commanders for planning and conducting joint special operations in the theater, ensuring that SOFs capabilities are matched to mission requirements, exercising operational control of SOFs for joint special operations, and advising the Combatant Commanders and component commanders in theater on the proper employment of SOFs. The USCOMSOC provides funding and personnel for the SOCs, but each SOC reports directly to the geographic Combatant Command. [Ref. 56, p. 13]

# LIST OF REFERENCES


1. Business Executives for National Security (BENS Commission), Call to Action, Washington D.C., February 1997

2. Business Executives for National Security (BENS Commission), Building confidence: Partnering between the Defense Department and the Private Sector, Washington, D.C., 1998

3. Byrne, John A., How Jack Welch Runs GE, BusinessWeek Online, May 28, 1998, [http://www.businessweek.com/1998/23/b3581001.htm]

4. Correl, John T., Evolution of the Aerospace Force, Air Force Magazine Online, June 2001, Vol. 84, No. 6., [http://www.afa.org/magazine/editorial/06edit01.html]

5. CPA Australia, Submission to the Victorian Public Accounts and Estimates Committee, Inquiry into Corporate Governance in the Victorian Public Sector, May 2000, [http://www.cpaonline.com.au/01_information_centre/04_ps_account/docs/corporate_gov_vicpubsec.pdf]

6. Davis, Paul K., 100 Decisive Battles: from ancient times to the present, Santa Barbara, CA, 1999

7. Dellert, Gregg M., An Analysis of the Impact of Reliability and Maintainability on the Operating and Support (O&S) Costs and Operational Availability (Ao) of the RAH-66 Comanche Helicopter, Naval Postgraduate School, Monterey, CA, December 2001

8. Dupuy, Ernest R., and Dupuy, Trevor N., The Harper Encyclopedia of Military History, Fourth Edition, Harper Collins Publishers, New York, NY, 1993

9. Dupuy, Trevor N., The Evolution of Weapons and Warfare, The Bobbs-Merril Company, Inc., Indianapolis, NY, 1980

10. Dupuy, Trevor N., Numbers, Predictions and War: Using History to Evaluate Combat Factors and Predict the Outcome of Battles, Hero Books, Fairfax, VA, 1985

11. Engels, Donald W., Alexander the Great and the Logistics of the Macedonian Army, University of California Press, Berkeley, CA, 1978

12. Garrison, Ray, Managerial Accounting, Cincinatti, OH, 2000

13. Garrison, and Noreen, Managerial Accounting website [http://www.mhhe.com/business/accounting/garrison/Student/olc/garrison9emgracct_s/ch08s_cs.html] accessed in November 2002

14. Goldwater-Nichols Department of Defense Reorganization Act, Public Law 99-433, October 1, 1986

15. Hansen and Mowen, Management Accounting, Cincinnati, OH, 2000

16. Harrison, Jeffrey S., St. John, Caron H., Foundations in Strategic Management, 2nd ed., South-Western College Publishing, Cincinnati, OH, 2002

17. Kang, Keebom, DoD Inventory Management Cultural Changes and Training in Commercial Practices, Department of Systems Management, Naval Postgraduate School, Monterey, CA, March 1998

18. Kang, Keebom, Notes for MN4310 Logistics Engineering, Department of Systems Management, Naval Postgraduate School, Monterey, CA, spring 2002

19. Kang, Keebom, Cycle Time Reduction: Why Do We Care About Fast Turn-around Time, Teaching Slide from MN4310 Logistics Engineering, Naval Postgraduate School, Monterey, CA, April 2002

20. Kang, Keebom, Spreadsheet Decision Support Model for Aviation Logistics, Naval Postgraduate School, Monterey, CA, September 1993

21. Kang, Keebom, Gue, Kevin R., Eaton, Donald R., Cycle Time Reduction for Naval Aviation Depots, Proceedings of the 1998 Winter Simulation Conference, Eds. D. J. Medieros, E. F. Watson, J. S. Carson, and M. S. Manivannan, pg. 907-912, 1998

22. Kidport Reference Library, Science website, [http://www.kidport.com/RefLib/Science/Dinosaurs/Dinosaurs.htm], accessed on November 19, 2002

23. M. Thomas Davis, Fixing the FYDP (Draft), February 5, 2001, [http://www.capitol.northgrum.com/files/FYDP.pdf]

24. Matthews, Dave, Principles of Acquisition and Program Management Teaching Slide from MN3331, Naval Postgraduate School, Monterey, CA, 2002

25. McCord, W.J., McCord Consulting Group website [http://www.mccordcg.com/nf_lean_thinking.htm], accessed on November 10, 2002

26. McInerney, Thomas G., (Lieutenant General, USAF (Ret.), Former President and CEO, BENS), Statement before the National Defense Panel of the QDR pursuant to the Military Force Structure Review Act Of 1996

27. Mutty, John E., Editor, Practical Financial Management: A Handbook of Practical Financial Management Topics for the DoD Financial Manager, 3rd Edition, Revision 6, Naval Postgraduate School, Monterey, CA, June 2002

28. National Defense Authorization Act For Fiscal Year 2000, Public Law 106-65, 106th Congress, Title IX-Department of Defense Organization and Management, Subtitle A-Department of Defense Strategic Planning

29. Naval Postgraduate School, Web based course “Financial Management in the Armed Forces,” Monterey, CA

30. Office of the Secretary of Defense, Unmanned Aerial Vehicles Roadmap 2000 – 2025, Washington, DC, April 2001

31. Office of the Secretary of Defense, Cost Analysis Improvement Group (CAIG), Operating and Support Cost Estimating Guide, May 1992, [http://www.dtic.mil/pae]

32. Office of the Under Secretary of Defense (Comptroller), National Defense Budget Estimates for FY 2003, Washington, D.C., March 2002

33. Office of the Under Secretary of Defense for Personnel and Readiness ODUSD(PI)(RQ), Defense Manpower

Requirements Report, Fiscal Year 2001, Washington, DC, May 2000

34. Philips, Carla R., Six Galleons for the King of Spain: Imperial Defense in the Early Seventeenth Century, Johns Hopkins University Press, Baltimore, MD, 1992

35. Prahalad, C.K. and Hamel, Gary, The Core Competence of the Corporation, Harvard Business Review, May-June 1990, pp. 79-91

36. Quadrennial Defense Review - May 1997, Section VIII, Achieving a 21st Century Defense Infrastructure, [http://www.fas.org/man/docs/qdr]

37. Rutenberg, David C., Jane S. Allen, The Logistics of Waging War, American Logistics 1774-1985, Air Force Logistics Management Center, Gunter Air Force Station, AL, 1996

38. Sawyer, Ralph D., Mei-chun Sawyer, The Seven Military Classics of Ancient China, translation and commentary, Westview Press, Inc., Boulder, CO, 1993

39. Secretary of Defense, Annual Report to the President and the Congress, Washington D.C., 2002

40. Secretary of Defense, Annual Report to the President and the Congress, Washington D.C., 2001

41. Simmons, Robert, Performance Measures & Control Systems for Implementing Strategy, Prentice Hall, Upper Saddle River, NJ, 2000

42. Stickney, Clyde P. and Weil, Roman L., Financial Accounting: An Introduction to Concepts, Methods, and Uses, Harcourt College Publishers, Fort Worth, TX, 2000

43. Strassman, Paul A., 'Tail' over 'Teeth'?, Computerworld, April 1, 2002, [http://www.computerworld.com/management topics/management/story/0,10801,69662,00.html]

44. Texas A&M Accounting website, online teaching notes from Dr. James C. Flagg,[http://acct.tamu.edu/flagg/1], accessed in November 2002

45. The CFO Council’s Cost Accounting implementation guide online, [http://www.va.gov/cfo/pubs/costguide/part2.htm] , accessed in November 2002

46. The Defense Homepage, [http://www.defensehomepage.com], accessed in October 2002

47. The Management Guru, online teaching notes from MGT499 at Hampton University, [http://www.mgmtguru.com/mgt499/ TN5_6.htm], accessed in October 2002

48. Under Secretary of Defense (Acquisition and Technology), Jacques S. Gansler, Definition of Total Ownership Costs (TOC), Memorandum for Secretaries of the Military Departments, November 13, 1998

49. United States Commission on National Security/21st Century, Creating Defense Excellence: Defense Addendum to Road Map for National Security, Washington D.C., May 15, 2001

50. United States General Accounting Office, DEFENSE BUDGET Observations on Infrastructure Activities, GAO/NSIAD-97-127BR, April 1995

51. United States General Accounting Office, FUTURE YEARS DEFENSE PROGRAM 1996 Programs is Considerably Different From the 1995 Program, GAO/NSIAD-95-213, September 1995

52. United States General Accounting Office, DEFENSE INFRASTRUCTURE Budget Estimates for 1996-2001 Offer Little Savings for Modernization, GAO/NSIAD-96-131, April 1996

53. United States General Accounting Office, DEFENSE HEADQUARTERS, Status of Efforts to Reduce Headquarters Personnel, GAO/NSIAD-99-45, February 1999

54. United States General Accounting Office, DEFENSE HEADQUARTERS, Status of Efforts to Redefine and Reduce Headquarters Staff, GAO/NSIAD-00-24, September 2000

55. United States General Accounting Office, DEFENSE ACQUISITIONS Higher Priority Needed for Army Operating and Support Cost Reduction Efforts, GAO/NSIAD-00-197, Washington, DC, September 2000

56. United States Special Operations Forces, Posture Statement, 2000, http://www.defenselink.mil/pubs/sof, accessed in November 2002

57. Wayne, Leslie, America's For-Profit Secret Army, New York Times, October 13, 2002

58. Woodward, Emily, Myers: Plans To Cut Headquarters Staffs May Be Adjusted, DefenseNews.com, November 12, 2002

# INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia
2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California
3. Marine Corps Representative
   Naval Postgraduate School
   Monterey, California
4. Director, Training and Education, MCCDC, Code C46
   Quantico, Virginia
5. Director, Marine Corps Research Center, MCCDC,
   Code C40RC
   Quantico, Virginia
6. Marine Corps Tactical Systems Support Activity
   (Attn: Operations Officer)
   Camp Pendleton, California
7. Professor John Mutty
   Naval Postgraduate School
   Monterey, California
8. Professor Bill Gates
   Naval Postgraduate School
   Monterey, California
9. Ambassador Luis A. Moreno
   Colombian Embassy
   Washington, DC.
10. Bernardo Ortiz
    Vice-Minister of Defense, Republic of Colombia
    Bogota, DC.
11. Tamara L. Campbell
    Naval Postgraduate School
    Monterey, California
12. Carlos H. Velasco
    Naval Postgraduate School
    Monterey, California